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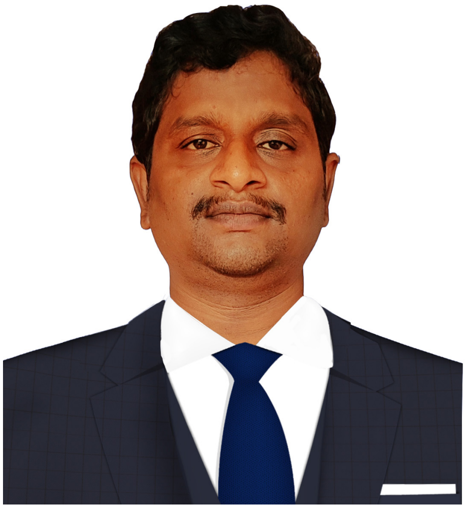
From the Desk of Editor-in-Chief



With immense humbleness and anticipation, I seek it's my pleasure to launch the September 2026 issue of the **"Krishi Netra"** a monthly e-Magazine subtitled "Invisible Vision on Farming" published by **GRN Creatives**. On behalf of the Krishi Netra Editorial Team, I would like to take this opportunity to thank our authors, editors, reviewers and all of them who have volunteered to contribute to the successful release of the first (December) issue of the e-Magazine.

The magazine aims to provide a common platform for the scientific community, research scholars and other readers to publish their ideas, new inventions, research findings etc., to provide the invisible insights for betterment of the farming community. Krishi Netra magazine is primarily focused on the areas of Agriculture, Horticulture, Precision Farming, Fisheries & Animal Sciences, Agriculture Engineering, Agribusiness Management, Food & Dairy Technology, Bio-Sciences/ Life-Sciences, Biotechnology & Biochemistry, Environmental Science &Forestry, Organic Farming, Sericulture and Home Science.

As we turn the pages of Krishi Netra, let us celebrate the unsung heroes, the farmers, the agri-entrepreneurs, the scientists, and the agri scholars. Together, we delve into the realms of sustainable practices, agro ecology, and the transformative power of technology, ensuring that the seeds we sow today yield a bountiful harvest for generations to come.

May this magazine be a source of inspiration, knowledge, and appreciation for the remarkable journey from seed to harvest. Join us on this exploration of the fields that bind us all, as we cultivate a deeper understanding and appreciation for the intricate dance of life on the farm.

I warmly welcome the authors with their contributions that can meet the practical appliances with an integrated/ convergent approach. I wish, with all your support I could see a very bright prospects for Krishi Netra magazine as an eye opener in serving the needs of the farming community.

We look forward for your valuable feedback!
For any questions/ suggestions/ concerns, please contact us: krishinetra@gmail.com
Thank you.

Editor-in-Chief
Gangisetty Srikanth Kumar

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From Fields to Higher Value: India's New Push for High-Value Crops

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Abstract

Indian agriculture is gradually transitioning from a food-grain focused production system to a more varied and higher-value agricultural approach for improved income, employment, and market prospects. Crops of significant value such as coconut, cashew, cocoa, sandalwood, agarwood, walnut, almond, and chilgoza hold substantial potential to boost RTAs, enhance value addition, and generate employment in rural and tribal regions. The Union Budget 2026–27 emphasized the necessity of encouraging high-value crops in targeted regions by designating funds for their growth in suitable areas. Coconut, cashew, cocoa, and sandalwood have potential in coastal regions, while the North-Eastern area is ideal for cultivating agarwood. Similarly, the hilly and Himalayan regions are recognized to possess significant potential for the cultivation of walnuts, almonds, and chilgoza. Expanding into these crops can aid in diversifying export markets, reducing dependence on conventional crops, improving land use efficiency, and strengthening the agro-processing industry. However, the marketing of their products is constrained by climate threats, limited farm acreage, substantial investment needs, insufficient technical knowledge, quality and safety regulations, and poor post-harvest infrastructure. These limitations can be effectively tackled by offering location-specific recommendations, enhancing skills, supplying improved planting materials, implementing climate-smart technologies, utilizing digital extension, adding value, and establishing market connections in agricultural extension. Enhancing the capacity of Farmer Producer Organizations (FPOs) and fostering collaborations among farmers, researchers, extension agencies, government bodies, and the private sector can further boost the value chain of high-value crops. Thus, regional diversification of activities with effective extension services and the development of value chains for market-focused activities can greatly influence the increase of farm incomes without jeopardizing the production of essential food crops.

Keywords: High-value crops, diversification, farm revenue, agricultural extension services, value enhancement.

Introduction

A paradigm change from a food grain-centric approach to one that is more varied and focused on greater revenues is taking place in Indian agriculture. The Indian government's increasing focus on high-value crops has given this shift a major boost. Funds for higher-value agriculture has been allocated Rs. 350 crores for the promotion of high-value crops in particular regions, were announced in the Union Budget 2026–2027.

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What are high-value crops?

Fruits, vegetables, flowers, spices, plantation crops, medicinal and fragrant plants, and some tree-borne nuts and seeds are examples of horticultural and commercial crops that are considered high value because they have the potential to produce larger returns per unit area. Downstream processing, packing, storage, shipping, branding, and marketing activities provide value and create jobs in addition to improving farm-gate returns.

Government's Region-Specific Push for High-Value Crops

1. Coastal Regions: Coconut, Cashew, Cocoa and Sandalwood

- A high-value product, coconuts support the livelihoods of around 30 million people, nearly 10 million of whom are farmers. In 2024–2025, the Indian economy will get Rs. 4,349 crore (US$513 million) from coconuts and coconut products. In 2024–2025, India produced over 13.97 million tons of coconuts on 2.19 million hectares of land. Kerala made up the greatest portion of the total production, followed by Tamil Nadu, while Andhra Pradesh had the highest yield. The goal of the Coconut Promotion Scheme is to replace low-yielding, outdated coconut palms with high-yielding ones.
- Other significant plantation crops in the nation are cocoa and cashew. With an export value of over US$369 million in 2024–2025, India is the biggest exporter of cashew nuts. In southern India, cocoa is mostly produced as an intercrop with coconut and arecanut, yielding approximately 32.91 thousand tons and US$296 million in exports.
- Sandalwood (Santalum album) is a valuable commodity that is traditionally farmed in some states for its heartwood and essential oil. To satisfy the demand worldwide, it is necessary to take advantage of the opportunity to advance scientific agriculture and value addition. Additionally, it would create new opportunities for rural residents and agribusinesses in states like Tamil Nadu, Odisha, and Karnataka.

2. North-East: Agarwood / Oud

The intensely scented, resinous heartwood of the Aquilaris tree, known as agarwood or oud, has immense potential in the global market for religious incense, traditional medicine, and perfumes. The primary habitat for agarwood and oud is the northeast. With consistent cultivation and suitable processing that complies with CITES requirements, this crop has enormous potential for value addition and revenue generation. Additionally, it would give rural residents and indigenous people job opportunities.

3. Hilly regions: Walnut, Almond and Pine Nut

Walnut, almond, and chilgoza (pine nut) are high-value horticultural crops of the country, being abundantly grown in the hilly tracts of Jammu and Kashmir, Himachal Pradesh, and Uttarakhand. Jammu and Kashmir is the leading producer state of both walnut and almond, while Himachal Pradesh is the largest producer of chilgoza that mainly caters to the tribal population. The Budget provides an opportunity for high-density cultivation and rejuvenation of existing plantations for enhancing production, diversification, and value addition with higher income and employment generation potential.

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Why High-Value Crop Diversification Matters

1. Increased Farm Income: When scientifically managed and supported by appropriate markets, high-value crops can yield significantly higher returns per unit of land than many traditional crops. Because of this, diversification is a crucial tactic for raising farm income.

2. Export Prospects: India's agricultural exports already include crops like coconut, cashew, and cocoa. Improved packaging, branding, processing, and quality assurance can raise their worth in both domestic and foreign markets.

3. Rural and Tribal Employment: In areas with few agricultural options, crops like agarwood, chilgoza, and temperate nuts can generate revenue. More jobs in rural areas can be created thru processing and marketing.

4. Less Reliance on a Single Crop: Crop diversification can lessen an over-reliance on a small number of conventional crops. In addition to offering farmers many revenue streams, a diversified farming system can lower the risks brought on by changes in the cost or yield of a single crop.

5. More Agro-Processing Opportunities: A variety of rural industries can be supported by high-value crops. Cocoa supplies raw materials for the chocolate sector, cashew supports processing facilities, and coconut can give raw materials for oil, milk, and other items.

6. Better Use of Land: Another significant potential is offered by intercropping. For instance, arecanut and coconut can be grown alongside cocoa. These systems enable farmers to earn more money without needing more land.

7. Environmental Opportunities: Some valuable crops can also help achieve environmental objectives. While agroforestry-based cultivation of crops like agarwood can combine revenue generating with tree-based agricultural methods, cashew cultivation can help turn underutilized or degraded land into profitable usage.

Challenges in Promoting High-Value Crops

1. **Climate Risk:** Weather can have a significant impact on high-value crops. In addition to quantity, their quality, size, color, texture, and shelf life all affect their market worth. During flowering and harvesting, heatwaves, sudden downpours, or other extreme weather conditions can impair yield and quality.

2. **Small and Disjointed Landholdings:** A lot of farmers run their businesses on small holdings. Achieving economies of scale in production, processing, and marketing may be challenging as a result. For instance, the abundance of small-scale coconut growers emphasizes the necessity of group strategies like Farmer Producer Organizations.

3. **Quality and safety standards:** Strict quality, food safety, and phytosanitary standards are required in international markets. If Indian high-value crops are to successfully compete in premium markets, they must meet these requirements.

4. **High Initial Investment:** Before producing noticeable profits, perennial crops like sandalwood and agarwood may need a sizable initial investment. As a result, small and marginal farmers might require

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institutional support, insurance, and finance.

5. **Lack of Technical expertise:** Specialized expertise on planting materials, crop management, nutrition, pest and disease control, harvesting, and post-harvest processing is necessary for high-value crops. Farmers may find it challenging to successfully embrace these crops if they do not receive sufficient technical assistance.

6. **Inadequate Post-Harvest Infrastructure:** High output does not ensure high profits. Proper grading, packing, storage, cold-chain facilities, transportation, and processing are necessary for high-value and perishable commodities. Farmers may lose money and get lower prices if there is insufficient infrastructure.

Role of Agricultural Extension

With location-specific technical advice, training, and market data, agricultural extension can help diversify high-value crops. Extension organizations can assist farmers in adopting successful crops by promoting enhanced technology, value addition, FPOs, and digital advisory. High-quality planting materials, production, post-harvest management, and marketing are further supported by government initiatives like MIDH.

The Way Forward

1. Future high-value agricultural strategies should focus on growing both the farmed area and the value chain.

2. Quality seeds, financing, irrigation, climate-smart technologies, scientific extension services, and market connections must be given to farmers. Processing, storage, packing, branding, certification, and export promotion must also be prioritized.

3. It is also crucial to concentrate on crop-climate geopolitics; states that are coastal, northeastern, hilly, and Himalayan have unique agroclimatic resources and potential. Produce unique to a given area can maximize resource utilization and aid in effective diversification.

4. To add value, farmers, FPOs, research organizations, extension agencies, government departments, and the corporate sector mst collaborate.

Conclusion

Higher farm returns, employment prospects in tribal and rural regions, value addition, and new opportunities for India's agricultural products in the international market are all made possible by coconut, cocoa, cashew, sandalwood, agarwood, walnut, almond, chilgoza, etc. High-value crops, however, should be pushed as an alternative business to augment the farm revenue from conventional crops rather than overshadowing the significance of basic food crops. Diversifying into higher-value production systems, in my opinion, has a great deal of potential to increase farm income, but it necessitates the efficient management of risks connected to biophysics, finances, technology, post-harvest, and markets.

Agricultural extension will be essential in this area by informing farmers, encouraging and implementing

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new production and processing technologies, enhancing FPOs, and connecting them with market participants. The primary goal in agricultural extension has always been to encourage farmers to cultivate a profitable crop. By concentrating on management, production, and processing methods, agricultural extension can play a crucial role in unlocking the potential of high-value crops in India. To summarize, for the farmers with higher incomes, it is essential to select a crop that fits the agro-climatic area, enhance its value, connect it to the best market, and optimize the farm-gate price.

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Bacterial Stalk Rot of Maize an Emerging Threat to Maize Production and Its Management

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Abstract

Maize (*Zea mays* L.) is a valuable cereal crop however, many diseases negatively impact its productivity with the bacterial stalk rot (BSR) of *Dickeya zeae* being one of the emerging economically important diseases. This pathogen is distributed across all the main areas where maize grows and thrives under warm and humid climate conditions with abundant precipitation. Symptoms of BSR may include the appearance of water-soaked lesions on stalks, softening, darkening of tissues, offensive smell, wilting, lodging and early death of plants. BSR is a destructive disease, especially if it develops prior to flowering. The broad host range, adaptation and soil, water and plant transmission capacities of *D. zeae* complicate the development and spreading of the disease even further. Field sanitation, rotation of crops, drainage and irrigation management, balanced fertilization, use of resistant cultivars, biological control agents and appropriate chemicals are the ways to control this disease. Among the potential antagonists, *Bacillus* and *Pseudomonas* spp. were found to be effective. Integration and environmentally sustainable management practices are necessary to reduce losses from BSR and increase productivity of maize.

Keywords: Maize, *Dickeya zeae*, bacterial stalk rot, disease distribution, symptomology, yield loss, biological control, integrated disease management.

1. Introduction

Maize (*Zea mays* L.) is one of the most important cereal crops grown across the world and is widely adapted to diverse agro-climatic regions. Due to its high genetic yield potential, maize is commonly called the “Queen of Cereals”. Maize is cultivated in 193.7 M ha area, with 1147.7 MT production and 5.75 tonnes/ha productivity in more than 170 countries (FAOSTAT, 2020). In Telangana, maize cultivation ranks third after rice and cotton, covering an area of 0.490 million ha, with production of 2.77 million tonnes and productivity of 5.67 tonnes ha^{-1} (Indiastat, 2024 and Kiran *et al*., 2026).

The production of maize is sometimes affected by biotic stresses such as diseases like leaf blights, banded leaf and sheath blight, and stalk rots. One type of stalk rot that poses great threat to maize during the *kharif* season is bacterial stalk rot (BSR). This is because BSR is caused by *Dickeya zeae* (formally known as *Erwinia chrysanthemi* pv. *zeae*) (Samson *et al*., 2005 and Jatoth *et al*., 2022). BSR usually occurs about 40 to 60 days after sowing. The symptoms of BSR include water-soaked lesions, darkened soft tissues of the basal stem, bad odor, rapid decay of tissues, wilting and plant lodging (Jatoth *et al*., 2024).

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Several bacteria are associated with maize stalk rot, of which *Dickeya zeae* is considered the most important and destructive pathogen. Bacterial stalk rot is a common phenomenon that occurs in Asian countries, Africa, North America, South America, and Oceania. It results in rotting, softening of stalk tissues, wilting, lodging and considerable yield losses, particularly in highly yielding and susceptible maize varieties. Stalk rot has been recorded in some Indian states growing maize, including Andhra Pradesh and Telangana (Jatoth *et al*., 2022 and Jatoth *et al*., 2024).

Dickeya zeae is an extremely versatile bacterium associated with soil and water with wide-ranging hosts. Besides maize, species of the genus *Dickeya* can affect valuable economic crops like bananas, potatoes, rice, tomatoes, carrots, onions, and a number of ornamental plants. The bacteria can be transferred from one plant to another by means of soil, rainwater, irrigation water, infected planting materials, and many other possible modes. Warmer weather and high levels of humidity can promote the occurrence and spread of the disease. Climate change, transportation of plant materials, and the prevalence of irrigation water can create favorable conditions for survival and dispersal of the bacteria *D. zeae*. This wide host range and environmental adaptability of the disease make bacterial stalk rot a serious problem for sustainable maize cultivation (Rajender *et al*., 2021 and Jatoth *et al*., 2022).

Management of BSR can be achieved through an integrated approach that involves biological, cultural, and chemical approaches. Beneficial microorganisms have been identified as promising biocontrol agents for such purposes. *B. amyloliquefaciens* DSBA-11, *P. fluorescens, P. parafulva,* and *B. velezensis* were found to be highly antagonistic to D. zeae (Kumar *et al*., 2017; Li *et al*., 2020; Jatoth *et al*., 2022). Also, actinomycetes have been identified to show inhibition against *E. chrysanthemi* (Karkouri *et al*., 2010). The use of *Bacillus*, *Pseudomonas*, and actinomycetes may prove to be very significant in sustainable control of BSR. Further field trials with these microorganisms are necessary to develop suitable measures for reduction of BSR-induced yield losses in maize.

2. Distribution of the disease

Bacterial stalk rot of maize caused by *Dickeya zeae* is widely distributed across major maize-growing regions of Asia, Africa, Europe, and the Americas. The disease was first reported in Egypt and has subsequently been recorded in countries including the USA, Japan, Mexico, China, Korea, Thailand, and Pakistan. In India, it occurs in several states, including Himachal Pradesh, Uttarakhand, Punjab, Uttar Pradesh, Rajasthan, Bihar, West Bengal, Andhra Pradesh, and Telangana. The disease is favoured by warm, humid conditions and frequent rainfall, which promote its development and spread. Its wide distribution and potential to cause severe losses in susceptible cultivars make it an important constraint to maize production (Rajender *et al*., 2021, Jatoth *et al*., 2022 and Jatoth *et al*., 2024).

3. Symptomology of bacterial stalk rot

Bacterial stalk rot caused by *Dickeya zeae* usually starts at the lower nodes and basal internodes as water-soaked, soft lesions that gradually turn light to dark brown or black due to tissue decay. As the disease progresses, infected tissues become soft, macerated, and foul-smelling, while leaves show yellowing, wilting,

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and drying. The rot may spread upward from the base or downward from the upper whorl, resulting in basal or top rot, followed by plant lodging and collapse (Rajender *et al*., 2021, Jatoth *et al*., 2022 and Jatoth *et al*., 2024). Under severe infection, plants may die prematurely, produce poorly filled cobs, and suffer considerable yield loss; dipteran larvae may also occur in decayed stalk tissues (Kushwaha *et al*., 2020).

4. Economic importance of bacterial stalk rot

Bacterial stalk rot (BSR) is a major disease of maize with the potential to cause substantial economic losses. Grain yield losses can range from 21 to 98%**,** and in severe epidemics may approach 99%. The extent of loss largely depends on the stage of infection, disease severity, and prevailing environmental conditions. Infection before flowering can result in almost complete yield loss, while infection shortly after flowering can cause about 85% reduction in yield.

Premature wilting of whorl leaves in maize plants due to bacterial stalk rot

Softening and rotting of tissues in the lower internodal region of maize plants

High temperature, humidity, and frequent rainfall favour disease development and spread. In India, BSR incidence has been reported at 10-39% in several maize-growing regions, with incidences as high as 46.85% in some areas. Under highly favourable conditions, disease incidence may reach 80-85%. In Telangana, incidence of about 13.32-30.89% has been recorded in major maize-growing districts. The disease can spread through rainwater and is often more damaging in high-yielding hybrids. The increasing incidence of BSR, combined with its ability to cause severe yield losses under favourable conditions, makes it an important economic constraint to profitable and sustainable maize production (Rajender *et al*., 2021, Jatoth *et al*., 2022)**.**

5. Management strategies

Effective management of bacterial stalk rot caused by *Dickeya zeae* requires an integrated approach combining cultural, biological, host resistance, and chemical methods.

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Cultural Practices: Regular field monitoring, removal and destruction of infected crop residues, crop rotation with non-host crops, proper drainage, and avoidance of excess irrigation can help reduce disease development and pathogen survival. Healthy planting material and clean farm tools should be used to minimize disease spread. Excess nitrogen should be avoided and applied in split doses, while balanced phosphorus and potassium nutrition can support healthier plants. Incorporation of well-decomposed compost or organic matter can improve soil health and promote beneficial microorganisms (Rajender *et al*., 2021, Jatoth *et al*., 2022)**.**

Biological Control: Beneficial microorganisms such as *Pseudomonas fluorescens*, *Bacillus* spp., and other plant-growth-promoting rhizobacteria (PGPR) have shown potential against *D. zeae*. Strains such as *P. fluorescens* MPF-5 and *P. fluorescens* SC3, *P. parafulva* SC11, and *Bacillus velezensis* have demonstrated antagonistic activity against the pathogen. These microorganisms can suppress *D. zeae* through antibiotic production, competition for nutrients, and induction of plant defence mechanisms. Bacteriophages are also being explored as potential biological control agents (Rajender *et al*., 2021, Jatoth *et al*., 2022)**.**

Resistant Breeding: Host resistance is an important and sustainable option because reliable chemical control of BSR is limited. Maize lines such as CM101, CM110, CM600 and Basi have shown tolerance to bacterial stalk rot. Identification of resistant germplasm requires effective screening methods, including stem injection, toothpick inoculation, and whorl inoculation, followed by selection and breeding of promising resistant genotypes (Rajender *et al*., 2021).

Chemical Management: Chemical management should be used as a component of an integrated strategy. Chlorination of irrigation water and application of bleaching powder have shown effectiveness in reducing disease incidence. Copper-based products, particularly when combined with suitable antibiotics, have also demonstrated disease-suppressing activity. However, chemical treatments should be applied carefully and in accordance with locally approved agricultural recommendations (Rajender *et al*., 2021, Jatoth *et al*., 2022).

Integrated Management: No single method provides complete and consistent control of bacterial stalk rot. Therefore, combining field sanitation, crop rotation, proper drainage and irrigation management, balanced nutrition, resistant cultivars, beneficial microorganisms, and suitable chemical treatments offers a more effective and sustainable approach for reducing BSR and protecting maize yield (Rajender *et al*., 2021).

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El Niño Risk Mitigation Strategies in Agriculture

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Introduction

Agriculture is highly dependent on the timely and adequate availability of water, making it particularly vulnerable to climate variability. Among the major climate phenomena influencing agricultural production, **El Niño** is one of the most important. El Niño refers to the periodic warming of the central and eastern tropical Pacific Ocean, which can alter atmospheric circulation and influence rainfall, temperature and extreme weather conditions across different parts of the world. In India, El Niño conditions are often associated with changes in the southwest monsoon, including delayed onset, prolonged dry spells, uneven rainfall distribution and increased temperatures. For farmers, the impact of El Niño is not limited to reduced rainfall. Moisture stress can affect seed germination, crop establishment, flowering, grain formation and final yield. Higher temperatures can increase crop water requirements, accelerate crop maturity and favour certain insect pests and diseases. Livestock may also experience heat stress, reduced feed availability and lower productivity. Therefore, **El Niño risk mitigation should begin before the season and continue throughout the crop cycle** through climate-smart crop planning, efficient water management, suitable crop varieties, contingency planning and diversification of farming enterprises.

Understanding the Agricultural Risks of El Niño

El Niño can influence agriculture through several interconnected pathways:

1. Erratic and deficient rainfall

Rainfall may become irregular, with long dry spells occurring between rainfall events. Even when seasonal rainfall is close to normal, poor distribution can create severe moisture stress during critical crop-growth stages.

2. Higher temperature

Above-normal temperatures increase evaporation and crop water demand. Crops may suffer from heat stress, particularly during flowering, pollination and grain filling.

3. Soil-moisture depletion

Reduced rainfall combined with high temperature rapidly reduces soil moisture. Light soils and shallow soils are particularly vulnerable.

4. Increased pest and disease risks

Temperature and humidity changes can influence pest multiplication and disease development. Crops

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weakened by moisture stress may also become more susceptible to pest attack.

5. Livestock stress

Heat stress reduces feed intake, milk production, reproductive performance and overall animal health. Scarcity of green fodder and drinking water can further increase the problem.

6. Reduced farm income

Lower yields, increased irrigation costs, higher input requirements and unstable market conditions can reduce farm profitability. Small and marginal farmers are particularly vulnerable because of limited access to irrigation, credit and other resources.

Major El Niño Risk Mitigation Strategies

1. Advance weather-based crop planning

The first line of defence against El Niño is **early and location-specific planning**. Farmers should follow seasonal climate outlooks, medium-range weather forecasts and advisories issued by agricultural universities, KVKs and government agencies.

Crop planning should consider:

- Expected rainfall and its distribution
- Soil type and available moisture
- Irrigation availability
- Crop duration
- Market demand
- Availability of drought-tolerant varieties
- Availability of seed for contingency crops

Farmers should avoid making crop decisions solely on the basis of the first rainfall event. Instead, sowing should be undertaken when sufficient soil moisture is available for successful germination and establishment.

2. Select drought-tolerant and short-duration varieties

During an El Niño year, choosing appropriate varieties can substantially reduce production risk. **Short-duration, drought-tolerant and heat-tolerant varieties** can escape terminal drought and complete their life cycle with less water. Where appropriate, farmers can replace long-duration crops with varieties that mature earlier. Seed should be procured and stored in advance so that contingency sowing can be undertaken quickly if the monsoon is delayed.

3. Timely sowing and optimum plant population

Timely sowing helps crops utilize available rainfall efficiently. However, sowing too early into inade-

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quate moisture can result in poor germination and weak plant stands. Maintaining an optimum plant population is equally important. Excessive plant density increases competition for water and nutrients. Appropriate spacing and seed rate can improve the availability of soil moisture to individual plants.

4. Promote moisture conservation

In-situ moisture conservation is one of the most effective strategies for rainfed agriculture. Farmers should reduce runoff and improve infiltration by adopting:

- Conservation furrows
- Broad-bed and furrow systems where suitable
- Contour farming
- Ridge and furrow planting
- Compartmental bunding
- Field bund strengthening
- Mulching
- Conservation tillage
- Crop residue management

Organic residues and mulches reduce evaporation and moderate soil temperature. Farm ponds and other water-harvesting structures can provide supplementary irrigation during critical crop stages.

5. Efficient water management

When water is limited, irrigation should be prioritized for the most sensitive crop-growth stages rather than applying water uniformly.

Critical stages may include:

- Germination and establishment
- Tillering or branching
- Flowering
- Pod or grain formation
- Fruit development

Drip and sprinkler irrigation can improve water-use efficiency where economically and technically feasible. Irrigation scheduling should be based on crop requirement, soil moisture and weather conditions.

6. Adopt contingency crop planning

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Contingency planning is essential when rainfall is delayed, deficient or interrupted by prolonged dry spells. If the monsoon is delayed, farmers may shift from long-duration crops to short-duration crops. If a standing crop fails due to prolonged moisture stress, re-sowing with suitable alternative crops should be considered based on the remaining growing period and available soil moisture. For rainfed areas, suitable contingency options may include pulses, millets, oilseeds and other short-duration crops depending on local agro-climatic conditions.

The principle is simple:

"Do not wait for crop failure—prepare the alternative crop plan before the crisis occurs."

7. Diversification of crops

Growing several crops rather than depending on a single crop reduces climate risk. A diversified farm may include cereals, pulses, oilseeds, vegetables, fodder and horticultural crops.For example, integrating pulses or oilseeds with cereal-based systems can improve income stability. Crop diversification also supports soil fertility, biodiversity and efficient utilization of available farm resources.

8. Integrated Farming System approach

An **Integrated Farming System (IFS)** is particularly useful for reducing the impact of climate variability. Crop production can be integrated with dairy, goat rearing, sheep rearing, poultry, fisheries, fodder production, horticulture and other enterprises. If crop yield is reduced during an El Niño year, income from livestock, poultry, fisheries or horticulture can partly compensate for the loss.

Farm residues can also be recycled:

Crop residues → livestock feed/bedding → manure → soil fertility → crop production

This improves resource-use efficiency while reducing dependence on external inputs.

9. Fodder and livestock management

El Niño-related drought can create severe fodder shortages. Farmers should therefore maintain fodder reserves before the onset of severe dry conditions.

Important measures include:

- Cultivation of drought-tolerant fodder crops
- Preservation of hay and silage
- Utilization of crop residues
- Provision of adequate drinking water
- Shade structures for animals
- Feeding during cooler hours
- Mineral supplementation as recommended

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- Regular monitoring for heat stress and disease

Livestock shelters should have good ventilation and protection from direct solar radiation.

10. Soil health management

Healthy soils have a greater capacity to store and supply water to crops. Increasing soil organic matter improves soil structure, infiltration and water-holding capacity.

Farmers should therefore promote:

- Farmyard manure
- Compost
- Vermicompost
- Green manuring
- Crop residue incorporation where appropriate
- Balanced fertilizer application
- Soil-test-based nutrient management

Excessive application of nitrogen should be avoided, particularly under moisture-stress conditions, because it can increase vegetative growth and crop water demand.

11. Weed management

Weeds compete directly with crops for scarce water, nutrients and sunlight. Under drought conditions, effective and timely weed management becomes even more important. Early weed control during the critical crop-weed competition period can conserve considerable soil moisture for the crop. Integrated weed management combining cultural, mechanical and chemical methods, where appropriate, should be adopted.

12. Pest and disease surveillance

El Niño-related changes in temperature and moisture may alter pest and disease patterns. Farmers should regularly inspect crops and follow **Integrated Pest Management (IPM)** principles.

Important measures include:

- Regular field scouting
- Use of pest-resistant varieties
- Seed treatment
- Installation of monitoring traps
- Conservation of natural enemies

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- Use of biological control agents
- Need-based pesticide application
- Avoidance of unnecessary pesticide sprays

Weather-based pest and disease advisories can help farmers take timely preventive action.

13. Use climate-smart agricultural technologies

Modern technologies can strengthen climate resilience. These include:

- Weather-based agro-advisories
- Soil moisture monitoring
- Drip and sprinkler irrigation
- Remote sensing
- Drones for crop monitoring and spraying where appropriate
- Digital weather information
- Mobile-based farmer advisories
- Precision nutrient management
- Farm mechanization and conservation agriculture

However, technology should be selected according to farm size, economic feasibility and local conditions.

14. Strengthen seed and input preparedness

Availability of quality seed immediately after crop failure is critical. KVKs, agriculture departments, seed agencies, farmer organizations and FPOs can maintain contingency seed reserves. Essential inputs such as seed, biofertilizers, fertilizers, plant-protection materials and fodder seed should be made available before the peak risk period.

15. Crop insurance and financial preparedness

Crop insurance can reduce the financial consequences of weather-related crop losses. Farmers should understand applicable crop insurance provisions, enrol within the prescribed period and maintain necessary records.Savings, access to institutional credit and collective procurement through Farmer Producer Organizations can further strengthen the financial resilience of small and marginal farmers.

Stage-Wise El Niño Risk Management

Before the season

Farmers should:

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- Study seasonal rainfall forecasts and local advisories.
- Select suitable drought-tolerant and short-duration varieties.
- Keep contingency seeds ready.
- Repair farm ponds, bunds and water-harvesting structures.
- Plan crop diversification.
- Arrange fodder and livestock drinking-water facilities.
- Prepare alternative crop plans.

During crop establishment

- Farmers should:
- Sow only when adequate soil moisture is available.
- Maintain optimum plant population.
- Treat seed before sowing.
- Control weeds at the appropriate stage.
- Conserve soil moisture through mulching and field management.
- Monitor weather forecasts regularly.

During prolonged dry spells

Farmers should:

- Prioritize available irrigation for critical crop stages.
- Reduce unnecessary irrigation losses.
- Apply protective irrigation where feasible.
- Use foliar nutrient application where recommended.
- Modify fertilizer application according to crop condition.
- Intensify pest and disease monitoring.
- Implement contingency measures if crop recovery is unlikely.

After crop failure

If crop recovery is not possible, farmers should avoid unnecessary expenditure on a severely damaged crop. Depending on the remaining season, soil moisture and local recommendations, they should consider:

- Short-duration alternative crops

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- Pulses
- Millets
- Oilseeds
- Fodder crops
- Green manure crops
- Other locally suitable contingency crops

The decision should be based on **soil moisture, date of crop failure, expected remaining rainfall and availability of inputs**.

Role of Krishi Vigyan Kendras

Krishi Vigyan Kendras (KVKs) can play a crucial role in reducing the impact of El Niño at the grassroots level. KVKs can provide location-specific advisories, conduct demonstrations on drought-resilient technologies, organize farmer training programmes, support contingency crop planning and facilitate access to improved seed and other inputs.

KVKs can also demonstrate:

- Climate-resilient crop varieties
- Integrated Farming Systems
- Water-saving technologies
- Natural resource conservation
- Integrated Pest Management
- Fodder management
- Crop diversification
- Weather-based farm advisories

Regular coordination among KVKs, the Department of Agriculture, district administration, farmer organizations and research institutions can ensure rapid dissemination of climate advisories to farmers.

El Niño and Integrated Farming System: A Resilience Model

An integrated farm can be compared with a diversified financial portfolio: **if one enterprise performs poorly, other enterprises can continue generating income**.

For example:

Crop + Dairy + Goat/Sheep + Poultry + Fisheries + Fodder + Horticulture

Such integration provides multiple sources of food, employment and income. Crop residues can support live-

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stock, livestock manure can improve soil fertility, farm ponds can support fisheries and irrigation, and farm wastes can be recycled into useful resources.

Thus, IFS is not merely a production system; it is a **risk-management strategy for climate-resilient farming**.

Key Message for Farmers

El Niño does not necessarily mean agricultural disaster. The severity of its impact depends greatly on **preparedness, timing and local adaptation**. Farmers who conserve water, select appropriate varieties, diversify crops and enterprises, follow weather-based advisories and maintain contingency plans can significantly reduce climate-related losses.

The Five Golden Principles

1. **Plan early** – prepare before rainfall becomes uncertain.
2. **Save water** – conserve every drop and use irrigation efficiently.
3. **Choose wisely** – select suitable short-duration and drought-tolerant crops.
4. **Diversify** – combine crops and livestock enterprises to spread risk.
5. **Act quickly –** implement contingency measures when drought or crop failure becomes evident.

Conclusion

El Niño presents a significant challenge to Indian agriculture by increasing the possibility of irregular rainfall, prolonged dry spells and higher temperatures. However, its adverse effects can be reduced through **climate-smart and anticipatory agricultural management**. Water conservation, drought-tolerant varieties, timely sowing, contingency crop planning, crop diversification, integrated farming systems, efficient irrigation, soil-health management, livestock care and weather-based advisories form the foundation of El Niño risk mitigation.

The future of rainfed agriculture depends not only on increasing production but also on increasing **resilience**. A farmer who is prepared with alternative crops, conserved water, diversified enterprises and timely technical advice is better equipped to withstand climatic uncertainty.

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Conjunctive Use of Irrigation in Tank Command Areas

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1. Introduction

Water has always been the foundation of agriculture. In Tamil Nadu, where rainfall is seasonal and often unpredictable, irrigation tanks have supported farming communities for centuries. These tanks collect and store rainwater during the monsoon and distribute it to agricultural fields through a network of channels. Besides providing irrigation, tanks recharge groundwater, support livestock, conserve biodiversity, and maintain the ecological balance of rural landscapes.

Over time, however, many tanks have lost their original storage capacity due to silt accumulation, encroachments, poor maintenance, and erratic rainfall. As a result, the water stored in tanks is often insufficient to meet the irrigation needs of crops throughout the growing season. Farmers therefore increasingly depend on wells and bore wells to bridge the gap between water demand and supply. Excessive groundwater pumping, however, can lower the water table and threaten the sustainability of agriculture.

A practical solution to this challenge is the **conjunctive use of irrigation**, which combines tank water and groundwater in a planned and balanced manner. Instead of relying entirely on one source, farmers make the best use of both resources. This approach not only ensures a reliable water supply but also improves water-use efficiency, enhances crop production, and protects groundwater resources for future generations.

2.Conjunctive Use of Irrigation

Conjunctive use of irrigation is the coordinated use of **surface water stored in irrigation tanks** and **groundwater obtained from open wells or bore wells**. The basic principle is simple: whenever sufficient tank water is available, it should be used for irrigation. As tank storage decreases or becomes exhausted, groundwater is used to supplement irrigation requirements.

2.1. Importance of Conjunctive Use in Tank Command Areas

Agriculture in tank command areas depends largely on the northeast and southwest monsoons. During years of good rainfall, tanks fill up and provide sufficient irrigation while simultaneously recharging groundwater. During drought years or prolonged dry spells, however, tank storage declines rapidly, leaving farmers dependent on groundwater. Using only tank water is risky because storage may not last until the end of the cropping season. On the other hand, depending solely on groundwater can lead to declining water tables, higher pumping costs, and drying of wells. Conjunctive use offers a balanced solution by integrating both resources. It ensures a dependable water supply while maintaining groundwater at sustainable levels.

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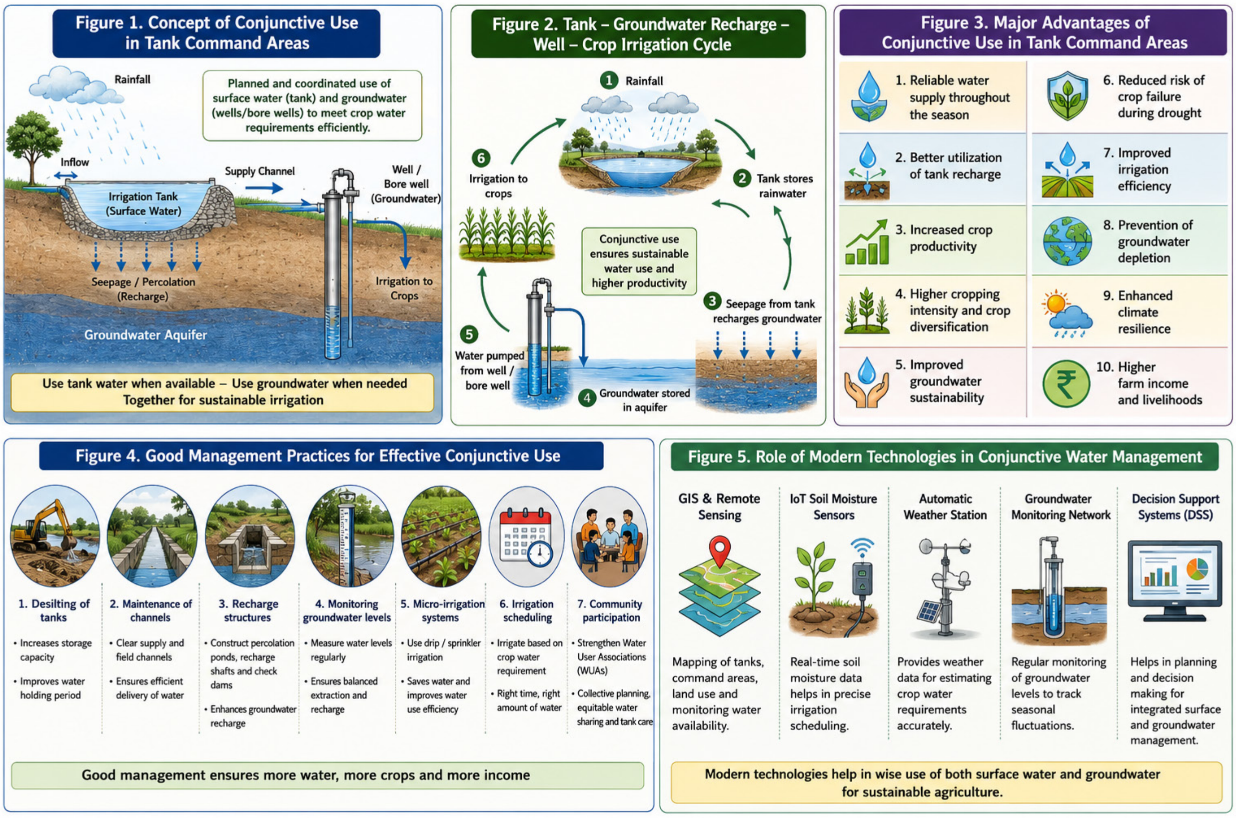

Figure 1. Concept of Conjunctive Use of Tank Water and Groundwater

2.2. Advantages of Conjunctive Use

2.2.1. Reliable Water Supply throughout the Crop Season

One of the greatest advantages of conjunctive use is the assurance of irrigation throughout the crop-growing period. Farmers can use tank water during the early stages of crop growth and switch to groundwater when tank storage becomes insufficient. This flexibility prevents interruptions in irrigation and protects crops from moisture stress during critical growth stages such as flowering and grain filling.

2.2.2.Better Utilization of Tank Recharge

Many people consider seepage from irrigation tanks as a loss. In reality, seepage performs an important ecological function by recharging underground aquifers. The groundwater stored beneath the tank command area can later be pumped through wells for irrigation. Thus, conjunctive use transforms what appears to be water loss into a valuable source of irrigation, significantly increasing the overall efficiency of water use.

2.2.3. Increased Crop Productivity

Timely irrigation is essential for healthy crop growth. When crops receive adequate moisture throughout the growing season, they develop stronger root systems, absorb nutrients more efficiently, and produce higher yields. Conjunctive use reduces water stress during critical growth stages, leading to better crop performance, improved grain quality, and increased agricultural productivity.

2.2.4. Higher Cropping Intensity and Crop Diversification

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Reliable irrigation encourages farmers to cultivate more than one crop each year. Instead of leaving land fallow after the monsoon season, farmers can grow pulses, oilseeds, vegetables, fodder crops, and other high-value crops using supplemental groundwater irrigation. This increases cropping intensity, diversifies farm production, and provides additional sources of income.

2.2.5. Sustainable Groundwater Management

Groundwater is one of the most valuable natural resources available to farmers. However, excessive pumping without adequate recharge eventually leads to declining water tables. Conjunctive use promotes sustainable groundwater management by encouraging the use of tank water whenever available while allowing natural seepage from tanks to replenish aquifers. Maintaining this balance between recharge and extraction helps ensure groundwater availability for future generations.

2.2.6. Reduced Risk of Crop Failure

Agriculture in semi-arid regions is highly vulnerable to uncertain rainfall. Even a short dry spell during flowering or grain development can significantly reduce yields. Groundwater serves as a dependable backup source during such periods, providing life-saving irrigation that protects crops from drought and minimizes production losses.

2.2.7.Improved Irrigation Efficiency

Efficient irrigation means applying the right quantity of water at the right time. Conjunctive use allows farmers to allocate tank water and groundwater according to crop requirements and seasonal availability. When combined with modern irrigation methods such as drip and sprinkler systems, this approach minimizes water losses due to evaporation and deep percolation, resulting in higher water productivity.

2.2.8. Greater Resilience to Climate Change

Climate change has increased the occurrence of erratic rainfall, prolonged droughts, and unpredictable weather conditions. Having access to both surface water and groundwater makes farming systems more resilient. Farmers can adjust irrigation practices according to changing climatic conditions, reducing the risks associated with weather uncertainty.

2.2.9. Increased Farm Income

Reliable irrigation translates into higher crop yields, better-quality produce, and improved economic returns. Farmers can cultivate high-value crops, extend the cropping season, and reduce the likelihood of crop failure. These benefits collectively enhance household income and improve the overall livelihood of farming families.

3. Management Practices for Successful Conjunctive Use

The success of conjunctive irrigation depends on proper planning and regular maintenance. Irrigation tanks should be desilted periodically to restore their storage capacity, while supply and field channels must be maintained to ensure efficient water distribution. Recharge structures such as percolation ponds and recharge wells can further enhance groundwater replenishment. Farmers should monitor groundwater levels regularly

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and adopt scientific irrigation scheduling based on crop water requirements. Water-saving technologies such as drip and sprinkler irrigation should be promoted to improve irrigation efficiency. Active participation of Water User Associations (WUAs) is equally important for ensuring equitable distribution of water and proper maintenance of tank systems.

4. Role of Modern Technologies

Modern technologies provide powerful tools for improving conjunctive water management. Geographic Information Systems (GIS) and remote sensing help monitor tank storage, command area conditions, and groundwater recharge. Automatic weather stations and soil moisture sensors enable farmers to schedule irrigation more accurately. Decision Support Systems (DSS), groundwater models, and mobile-based advisory services assist irrigation managers and farmers in making informed decisions for efficient use of both surface water and groundwater.

5. Relevance to Tamil Nadu

Tamil Nadu possesses one of the largest traditional tank irrigation systems in India. These tanks have sustained agriculture for generations while supporting groundwater recharge and rural livelihoods. Government initiatives such as **Kudimaramathu**, tank rehabilitation programmes, participatory irrigation management, and watershed development projects have revived many tank systems across the state. By integrating tank water with groundwater, Tamil Nadu can improve irrigation reliability, increase water-use efficiency, reduce groundwater depletion, and strengthen the resilience of agriculture against climate change. Conjunctive use is therefore an important component of sustainable water resource management in the state.

6.Conclusion

Conjunctive use of tank water and groundwater is much more than an irrigation practice—it is a sustainable approach to managing precious water resources. By using both sources wisely, farmers can ensure dependable irrigation, increase crop productivity, protect groundwater, and improve their livelihoods. At the same time, this approach conserves natural resources and strengthens the resilience of agriculture against climate variability. As water becomes an increasingly scarce resource, adopting conjunctive use in tank command areas will be essential for achieving sustainable agricultural development. With scientific planning, regular tank maintenance, modern irrigation technologies, and active community participation, conjunctive water management can secure the future of farming in Tamil Nadu and other tank-irrigated regions of India.

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The Human Gut Microbiota: Its Role in Health and Disease

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Abstract

The human digestive system contains a variety of microbes collectively called the gut microbiota. The gut microbiota mostly consists of bacteria but also comprises fungi, viruses, and archaea. The gut microbiota affects the interaction between the host and helps with digestion, vitamin production, metabolism, immune development, gut lining maintenance, and protection from pathogens. Factors that affect the gut microbiota include diet, age, genetics, lifestyle, environmental exposure, antibiotics, and stress. Dysbiosis is the disruption of the microbial balance in the gut and has been linked with diseases such as obesity, type 2 diabetes, inflammatory bowel disease, colorectal cancer, cardiovascular diseases, allergies, and some neurological disorders. The current scientific evidence shows that lifestyle choices, like the intake of fibre-rich food, probiotics, and prebiotics, can positively influence the gut microbiota.

Keywords: Gut microbiota, Human health, Dysbiosis, Probiotics, Prebiotics, Immunity, Chronic diseases.

1. Introduction

Human gastrointestinal (GI) tract has a complicated and dynamic system of microorganisms called gut microbiota, including mainly bacteria but also viruses, fungi, archaea, and others. The development of molecular biology and next generation sequencing has considerably increased our understanding about its composition and physiological importance for health.

Development of gut microbiota starts immediately after birth and continues to change drastically during infancy and childhood. Its composition is dependent on delivery way, breast feeding, nutrition, age, genetic predisposition, medications, exposure to environment, and lifestyle. Around the age of three years, the composition of the microorganism becomes relatively stable adult one, though it is still adaptable throughout life. The balanced microbiota usually has high diversity and functionality.

Physiological roles of the gut microbiota include digestion of dietary fiber, SCFA production, synthesis of vitamin K and some B group vitamins, mineral and nutrient metabolism, maintenance of the barrier function of the intestine, protection from pathogens, regulation of immune and inflammatory response and involvement in gut-brain axis and metabolic regulation.

Main classes of bacteria include Firmicutes, Bacteroidetes, Actinobacteria, Proteobacteria, Verrucomicrobia, and Fusobacteria. There are many beneficial microorganisms among which Lactobacillus and Bifidobacterium

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participate in intestinal physiology by producing metabolites, inhibiting pathogens, and regulating host immunity.

Alteration of the composition or functioning of microbiota, named dysbiosis, can be induced by such factors as improper usage of antibiotics, unhealthy diets, stress, aging, infection, and lack of physical activity. Dysbiosis has been found to correlate with obesity, type 2 diabetes, inflammatory bowel disease, colorectal cancer, cardiovascular diseases, allergies, autoimmune diseases, and neurodegenerative conditions. Recently increasing evidence shows that the gut microbiota can affect the progression and treatment of many diseases.

Thus, nowadays gut microbiota has become an interesting object of interventions in nutrition and therapy. Modification of diet, probiotics, prebiotics, synbiotics and faecal microbiota transplantation are investigated as means of restoration of gut microbiota balance.

2. The Healthy Human Gut Microbiota

The gut microbiome includes a large variety of microorganisms, bacteria, viruses, fungi, archaea, and protozoa that reside in the gastrointestinal (GI) tract and interact with the host. The gut microbiota helps maintain intestinal homeostasis, digestion, metabolic processes, nutrients' absorption, immunoregulation, and protects against pathogens. The largest number of microbes resides in the colon owing to favorable conditions.

The gut microbiota evolves from birth through childhood and early adulthood. The development of the gut microbiome is affected by the mode of birth, feeding, diet, age, antibiotics, and environmental factors. The relatively stable adult microbiome usually forms within 2-3 years after birth.

Healthy gut microbiota is diverse and balanced. Major groups of bacteria are Firmicutes, Bacteroidetes, Actinobacteria, Proteobacteria, Verrucomicrobia, and Fusobacteria. Two dominant phyla, which were traditionally considered, include Firmicutes and Bacteroidetes. Some genera, like Lactobacillus and Bifidobacterium, can be beneficial for gut health and production of microbial metabolites.

Microbiological communities vary along the gastrointestinal tract. There are a low number of microorganisms in the stomach because of its acid conditions; however, the amount of microorganisms increases gradually, reaching maximums in the colon. Eating healthy food containing fiber, fruits, vegetables, whole grains, and fermented foods is essential to ensure microbial diversity; otherwise, antibiotics' consumption, junk food, stress, and unhealthy lifestyle may cause imbalance of the gut microbiome.

2.1 Gut Microbiota and Immune System

The gut microbiota plays a central role in intestinal immune homeostasis by interacting with epithelial and immune cells. A balanced microbial community strengthens the intestinal barrier, restricts pathogen growth, and regulates innate and adaptive immune responses.

The intestinal barrier comprises epithelial cells, mucus, tight junctions, secretory immunoglobulin A (IgA), macrophages, dendritic cells, T lymphocytes, and Peyer's patches. Beneficial microorganisms enhance mucus production, maintain tight junction integrity, and stimulate antimicrobial peptide secretion, thereby limiting the entry of pathogens and toxins.

Dietary fibre fermentation by gut microbes produces short-chain fatty acids (SCFAs), particularly acetate,

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propionate, and butyrate. Butyrate provides energy to colonocytes and exerts anti-inflammatory effects by regulating cytokine production and promoting regulatory T-cell (Treg) activity.

Dysbiosis can impair the intestinal barrier and increase permeability, allowing microbial products such as lipopolysaccharides (LPS) to enter circulation and promote chronic inflammation. Such disturbances are associated with inflammatory bowel disease, allergies, obesity, type 2 diabetes, and other immune-related disorders. Probiotic foods and prebiotic-rich diets may support microbial balance, mucosal immunity, and intestinal health.

2.2 Gut Microbiota Benefits to the Host

Gut microbiota plays a role in the process of digestion, the metabolism of nutrients, the production of vitamins, immunity, and protection against pathogens. The fermentation of fiber leads to the formation of short-chain fatty acids (SCFA) including acetate, propionate, and butyrate. They serve as an energy source for colonocytes, improve the function of the intestine barrier, help regulate pH in the intestine, and regulate inflammation and pathogenic bacteria.

Microbes in the intestine take part in the production of vitamin K and B-vitamins such as folic acid, biotin, riboflavin, and vitamin B12, and they may enhance the absorption of some minerals such as calcium, magnesium, and iron. Microbes prevent colonization by pathogens through competition for nutrients and attachment sites and by the production of antimicrobial substances

Microorganisms play a part in glucose and lipid metabolism, in the transformation of bile acids, energy metabolism, and the metabolism of some active compounds of plants such as polyphenols. Gut microbiota diversity contributes to better metabolism and may help prevent obesity, type 2 diabetes, and metabolic syndrome.

In addition, gut microbes take part in the gut-brain axis by using signaling via nervous, hormonal, and immune systems. This way, microbes can affect mood and cognitive functions.

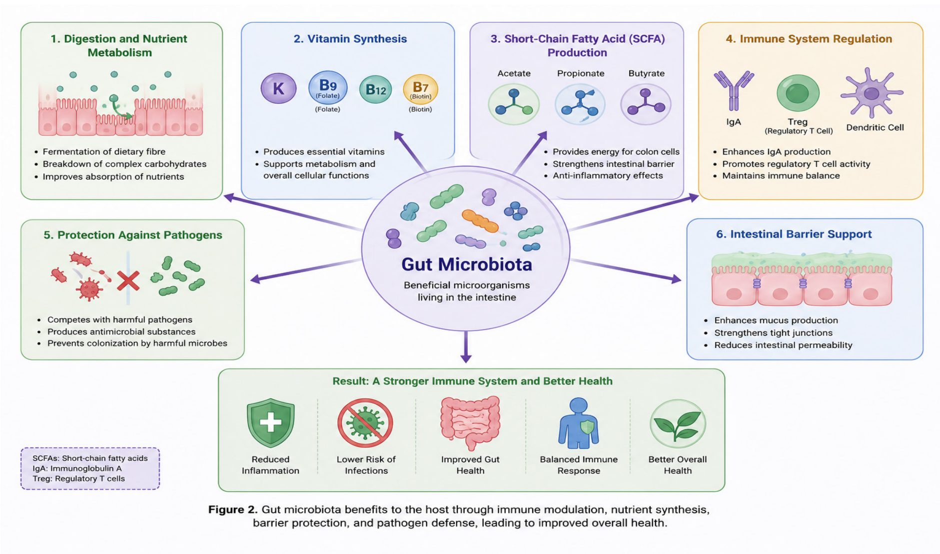

Figure 1: Gut microbiome and their health benefits

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2.3 Dietary Influence on Gut Microbiota

Diet is one of the key factors responsible for the gut microbiome structure and function. The diet characterized by the abundance of fiber, fruits and vegetables, whole grains, and fermented foods facilitates the development of microflora and triggers the formation of SCFAs that are known to preserve intestinal barrier integrity, immunity regulation, and inflammation prevention.

Alternatively, the diet with saturated fat, refined sugar, and high-processed foods can be associated with the decrease in microbial diversity and the development of dysbiosis that is related to metabolic and inflammatory diseases. Prebiotic supplements such as inulin and fructooligosaccharides have selective effect on microorganisms' growth, and probiotics and fermented foods are useful in terms of maintaining gut balance.

Polyphenol-containing products including berries, green tea, and cocoa could also be helpful in the increase in the number of microorganisms. It should be noted that diet changes could influence gut microbiome composition quite fast.

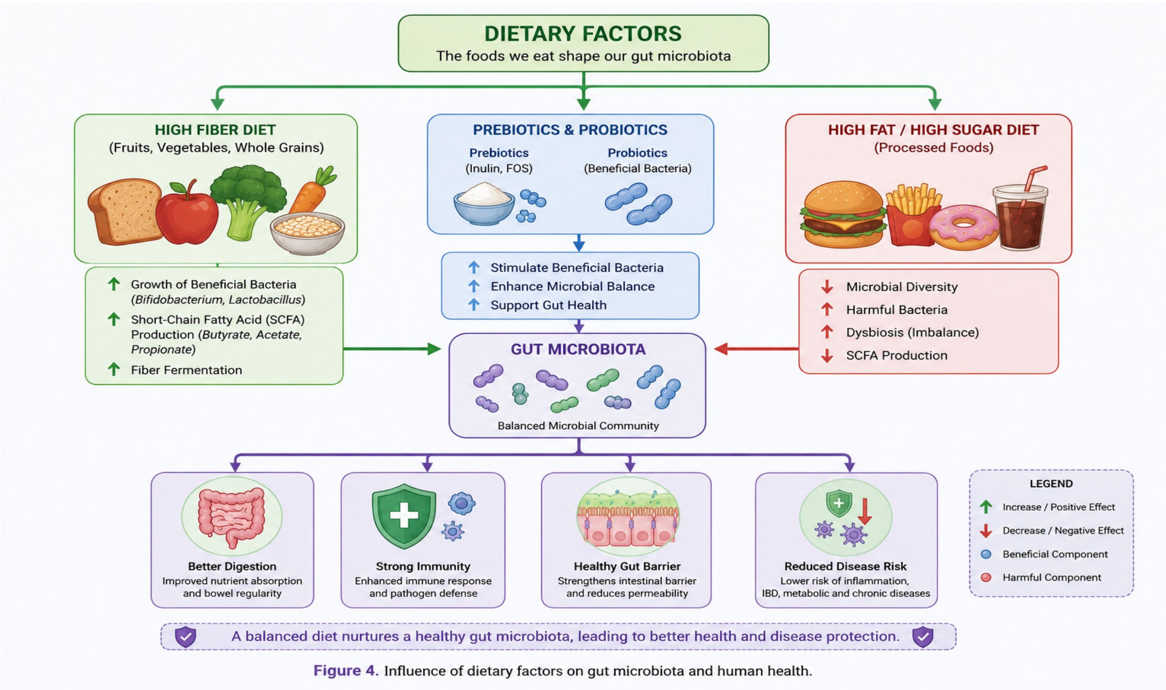

Figure 4. Influence of dietary factors on gut microbiota and human health.

Figure 2: Dietary factors that affect gut microbiome

3. Gut Microbiota and Human Diseases

Gut microbiota is essential for regulating metabolism, immunity, and gut homeostasis. Dysbiosis involves changes in the composition of the microbiota and reduced numbers of good bacteria that could result in inflammation, metabolism disorders, and immune dysfunctions in chronic diseases.

3.1 Obesity

Obesity is characterized by alterations in the gut microbial composition, reduction in its diversity, and change in the ratio between Firmicutes and Bacteroidetes. Dysbiosis could lead to enhanced energy extraction from food and inflammation and insulin resistance. Fiber-containing diet, prebiotics, and probiotics might be helpful for maintaining balance and healthy body weight.

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3.2 Diabetes

Dysbiosis could weaken the function of the intestinal barrier resulting in an increase in bacterial endotoxins in blood and the development of inflammation and insulin resistance. The decrease in the production of short-chain fatty acids (SCFAs) would result in additional disturbance of glucose regulation. Diet containing fiber, probiotics, and healthy lifestyle practices would facilitate maintenance of microbial balance and glycemia.

3.3 Inflammatory Bowel Disease

Crohn's disease and ulcerative colitis involve changes in the number of beneficial microorganisms, increase in potentially harmful bacteria, and weakening of the function of the intestinal barrier. This process could lead to excessive activation of the immune response and inflammation. Prebiotics, probiotics, and other methods targeting gut microbiota are under consideration as a possible supportive therapy.

3.4 Colorectal Cancer

The role of gut microbiota in colorectal cancer involves the processes of inflammation, immunity, and microbiota-produced metabolites. Certain bacteria such as Fusobacterium nucleatum promote tumor formation while SCFA-producing bacteria reduce its risk. A balanced diet rich in fibers and plant products could promote a preferable microbial community.

3.5 Cardiovascular-Diseases

Gut microbiota affects cardiovascular health due to its role in the regulation of lipid metabolism, inflammation, and production of various bioactive metabolites. Converting dietary choline and L-carnitine to trimethylamine, bacteria produce trimethylamine N-oxide (TMAO), which is related to cardiovascular risk. Balanced diet with a sufficient amount of fiber could improve the microbial community.

3.6 Neurological Disorders (Gut–Brain Axis)

The gut–brain axis is a bidirectional communication network connecting the gut microbiota with the central nervous system. Gut microorganisms produce neurotransmitters and metabolites that influence brain function, mood and behaviour. Dysbiosis has been associated with neurological and psychiatric disorders such as depression, anxiety, autism spectrum disorder and Parkinson's disease. Maintaining a healthy gut microbiota through balanced nutrition and probiotics may positively influence brain health and neurological function.

Table 1. Relationship between gut microbiota dysbiosis and major human diseases

S. No.	Disease	Gut Microbiota Changes	Major Health Effects
1.	**Obesity**	Increased Firmicutes, decreased Bacteroidetes	Increased energy harvest, chronic inflammation, weight gain
2.	**Type 2 Diabetes**	Reduced SCFA-producing bacteria, dysbiosis	Insulin resistance, impaired glucose metabolism
3.	**Inflammatory Bowel Disease (IBD)**	Decreased beneficial bacteria, increased pathogenic bacteria	Chronic intestinal inflammation, gut barrier dysfunction
4.	**Colorectal Cancer**	Increased *Fusobacterium nucleatum* and other pathogenic bacteria	Tumour progression, chronic inflammation

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5.	**Cardiovascular Diseases**	Increased TMAO-producing bacteria	Atherosclerosis, cardiovascular risk
6.	**Neurological Disorders**	Altered gut–brain microbiota	Depression, anxiety, autism, Parkinson's disease

4. Strategies to Improve Gut Microbiota

The presence of diversity and balance in a person's gut flora plays an important role in ensuring his digestion, immune system functionality, and other aspects of health. There are certain practices that affect microbial composition and contribute to the maintenance of gut homeostasis.

4.1 Probiotics

Probiotics are the live microorganisms that provide health benefits if consumed in sufficient quantities. The most common species of probiotics are Lactobacillus and Bifidobacterium. These species have been associated with promoting microbial balance, supporting the integrity of the intestinal lining, proper digestion, and immune responses. The major sources of dietary probiotics are yoghurt, kefir, and fermented vegetables.

4.2 Prebiotics

The prebiotics are non-digestible dietary components that positively affect the gut microorganisms. Among the sources of prebiotics one can find such products as garlic, onion, banana, oats, chicory root, and whole grains. Prebiotics promote the growth of beneficial microorganisms that produce short-chain fatty acids (SCFAs).

4.3 Synbiotics

Synbiotics are the combination of probiotics and prebiotics that promote the activity of beneficial microorganisms in the gut.

4.4 Healthy Diet and Lifestyle

The consumption of fruits, vegetables, legumes, whole grains, and fermented foods leads to the promotion of microbial diversity. Physical activity, sleep, stress management, and limited use of antibiotics support gut homeostasis. The excessive intake of processed foods, added sugar, and saturated fat may lead to dysbiosis.

Conclusion

The human gut microbiota is a complex and dynamic microbial community that plays a central role in maintaining gastrointestinal health, immune regulation, nutrient metabolism and overall physiological function. Disturbances in the gut microbial balance (gut dysbiosis) have been associated with several chronic diseases, including obesity, diabetes, inflammatory bowel disease, cardiovascular disorders, colorectal cancer and neurological conditions. Evidence suggests that a balanced diet rich in dietary fibre, along with probiotics, prebiotics, synbiotics and healthy lifestyle practices, can help maintain microbial diversity and support overall health. Continued research in this field will enhance our understanding of the gut microbiome and contribute to the development of more effective preventive and therapeutic strategies for improving human health.

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Hydroponics: The Future of Precision Agriculture and Sustainable Vegetable Production

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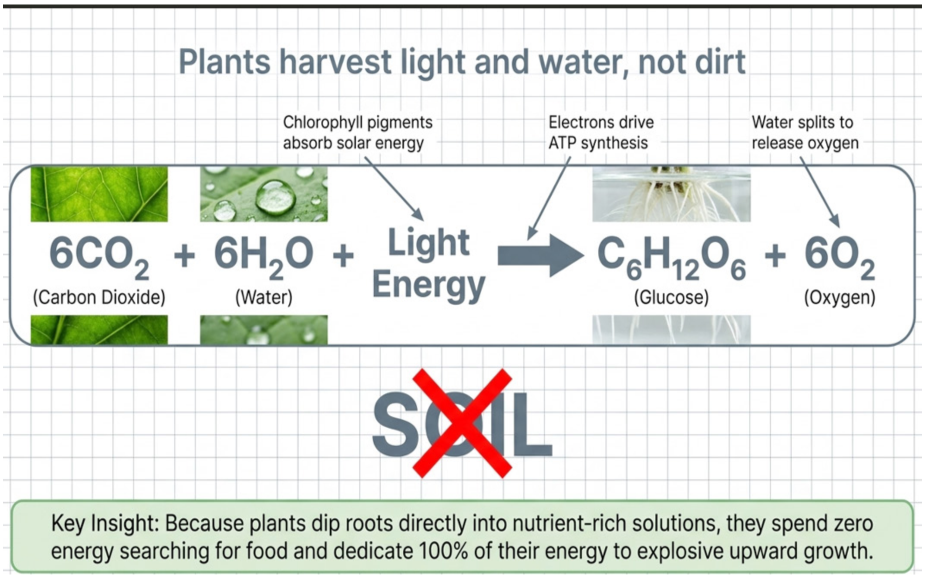
Abstract

With traditional soil-based agriculture increasingly constrained by rapid urbanization, climate vulnerability, and declining land fertility, soil-less culture stands out as a revolutionary alternative. Hydroponics, the technique of growing plants directly in nutrient-rich water solutions, redefines input-use efficiency in horticulture. By providing complete control over the root zone environment, this technology ensures rapid crop maturity, high-density cultivation, and exceptional quality in high-value vegetable crops. This article provides a comprehensive technical overview of hydroponic systems, resource optimization (pH and EC management), and its practical viability for both commercial growers and urban farming frameworks in India.

Keywords: Nutrient Film Technique (NFT), Water Conservation, Nutrient Management, Hydroponic Market.



Introduction: Shifting the Production Paradigm

The word *Hydroponics* originates from the Greek words *Hydro* (water) and *Ponos* (labor), translating literally to "water working." While popularized in the 1920s by Dr. William F. Gericke at the University of California, the underlying biological science is simple yet profound. The fundamental chemical equation of photosynthesis highlights that soil acts merely as a mechanical anchor and a nutrient reservoir, rather than a biological requirement for plant growth.

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Hydroponic system is a soilless cultivation technique in which vegetables are grown by supplying water and essential mineral nutrients directly to the root zone through a nutrient solution. When properly designed and managed, hydroponics can contribute to sustainable vegetable production by improving the efficiency of water, nutrients, land and other production resources. Sustainability in vegetable production aims to produce adequate quantities of nutritious vegetables while conserving natural resources, reducing environmental impacts and maintaining long-term productivity. Hydroponic systems can support these objectives through controlled management of the plant root environment.

By dissolving all essential macro- and micro-nutrients directly into water, hydroponics eliminates the energy plants traditionally spend expanding vast root systems to "search" for nutrients in soil. Instead, this saved metabolic energy is redirected entirely toward vegetative and generative biomass production, accelerating plant growth and maximizing economic yields.

Classification of Modern Hydroponic Structures

Hydroponic systems are broadly categorized into two fundamental operational designs, each adaptable to specific horticultural crops:

1. Liquid Hydroponic Systems (Pure Solution Culture)

In these systems, plant roots interact directly with the liquid nutrient solution without any solid growth medium.

- **Nutrient Film Technique (NFT):** Highly favoured for commercial production. A continuous, very shallow stream (a "film") of nutrient solution recirculates over the root masses via slightly slanted channels, ensuring simultaneous access to food and ample oxygen. It is globally recognized as the standard for leafy greens like lettuce.
- **Deep Water Culture (DWC):** This structure suspends plant roots directly into a deep reservoir of oxygenated water. Constant aeration is supplied via air stones to prevent root hypoxia. This system has shown exceptional results for leafy crops; for instance, trials at KVK Kashipur have successfully demonstrated high-quality lettuce production utilizing DWC frameworks.
- **Aeroponics:** An advanced variation where roots are suspended in an enclosed chamber and periodically misted with a fine spray of nutrient solution.

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2. Aggregate Hydroponic Systems (Substrate Culture)

These setups utilize inert solid materials to provide mechanical root anchorage while acting as a temporary holding zone for the nutrient flush. Common substrates include rockwool, perlite, vermiculite, gravel, expanded clay pellets, peat moss, sawdust, and locally abundant materials like coir dust (coconut fiber).

- **Drip System:** Individual emitters deliver a precise, slow drip of solution to the base of each plant container.
- **Ebb and Flow (Flood and Drain):** The aggregate bed is temporarily flooded with solution and then allowed to drain back into a central reservoir, alternating nutrient delivery with air intake.
- **Wick System:** A passive system where a nylon wick draws moisture up to an absorbent growth medium via capillary action, requiring no electrical pumps.


Strawberry in NFT Hydroponic System


Lettuce in NFT Hydroponic System

The Technical Matrix: Nutrient Solution Management

Precision management of the liquid ecosystem is the cornerstone of hydroponic success. Growers must actively monitor and regulate two key variables:

Electrical Conductivity (EC)

EC quantifies the concentration of dissolved mineral salts within the solution. Keeping the solution within the correct range prevents osmotic shock and ensures adequate nutrient uptake:

- **Too High EC:** Exerts high osmotic pressure on the root zone, preventing the plant from absorbing water effectively and inducing synthetic drought symptoms.
- **Too Low EC:** Starves the plant, leading to severe nutritional deficiencies and stunted growth.

Based on nutritional requirements, crops are classified into distinct feeding categories:

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- **Low Feeders (EC 0.8 – 1.5 mS/cm):** Lettuce, leafy greens, and short-duration herbs.
- **Medium Feeders (EC 1.5 – 2.5 mS/cm):** Solanaceous and cucurbitaceous crops such as tomatoes, bell peppers, and cucumbers.
- **High Feeders (EC 2.5 – 3.5 mS/cm):** Heavy-fruiting crops and melons.

pH Regulation

The pH level directly governs the chemical availability and solubility of nutrients. For the vast majority of hydroponic species, a precise pH range of **5.5 to 6.5** must be maintained. Deviations from this window cause specific ions to precipitate or bind up, resulting in rapid nutrient toxicity or deficiency symptoms.

Lettuce, Beans and Bok Choy Grown in Vertical Hydroponics System at the Department of Horticulture, GBPUA&T, Pantnagar

Horticultural Evaluation: Advantages and Disadvantages

Key Advantages:

1. **Exponentially Higher Yields:** Enables vertical space utilization and higher planting densities under protected or controlled structures.
2. **Unmatched Water Efficiency:** Closed-loop recirculating systems reuse runoff water, consuming significantly less water than traditional, open soil-based irrigation.
3. **Complete Elimination of Soil Pathogens:** Eliminates the threats of soil-borne pests, nematodes, and weeds, practically doing away with the need for aggressive chemical herbicides or soil fumigants.
4. **Accelerated Harvesting Cycles:** Plants achieve optimal health and reach market maturity much faster.
5. **Geographical Flexibility:** High-value crops can be grown off-season, inside urban buildings, on concrete terraces, or in regions completely devoid of fertile arable land.

Critical Disadvantages and Challenges:

1. **High Initial Capital Expenditure:** Setting up commercial units requires substantial investment in

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plumbing, automated dosing pumps, specialized tanks, substrate media, and potential supplemental grow lighting.

2. **Steep Learning Curve:** Demands precise technical expertise to calculate nutrient formulations, calibrate sensors, and maintain daily environmental balances.

3. **Strict Power Dependency:** Pure liquid systems (like NFT and DWC) rely entirely on electrical pumps. A prolonged power failure or mechanical breakdown can cause rapid root desiccation and crop mortality.

4. **Laborious Monitoring Routine:** Requires rigorous daily diligence to maintain proper pH, EC, and dissolved oxygen parameters.

Conclusion and Future Outlook

Hydroponics represents a major paradigm shift in modern horticulture, successfully moving vegetable production away from traditional constraints. Commercial configurations, such as cultivating crisp lettuce or vibrant strawberries in automated NFT channels demonstrate the immense scalability of soil-less cultivation.

For a developing agricultural landscape like India, this technology provides an excellent opportunity to produce clean, pesticide-free vegetables directly on rooftops, balconies, and urban peripheral zones of crowded cities, as well as in barren or degraded regions. As we advance, the focus of institutional research must center on developing low-cost localized components, identifying cheaper eco-friendly substrates, and refining automated nutrient delivery setups. Embracing hydroponics is no longer just an alternative farming method; it represents a highly sustainable, precision-driven path toward securing the food requirements of an expanding population.

If agriculture goes wrong, nothing else will have a chance to go right”

-M. S. Swaminathan

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Integrated Management of Postharvest Diseases in Tomato Using Conventional and Advanced Techniques

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Abstract

Tomato is a highly perishable vegetable crop that is susceptible to postharvest diseases caused mainly by fungal and bacterial pathogens. These diseases result in fruit decay, quality deterioration, reduced shelf life and significant economic losses during handling, storage, transportation and marketing. Integrated management provides a sustainable approach by combining conventional practices with advanced technologies. Conventional methods include careful harvesting, sanitation, sorting and grading, proper packaging, temperature and humidity management, refrigeration, heat treatments and the use of approved chemical or biological treatments. Advanced techniques such as hyperspectral imaging, machine learning, computer vision, biosensors and Internet of Things-based monitoring enable early disease detection and continuous assessment of storage conditions. Emerging technologies, including cold plasma, ultraviolet treatment, ozone, ultrasound, electrolysed water, edible coatings and smart packaging, may further reduce microbial growth while maintaining fruit quality. Integrating these approaches can minimise postharvest losses, extend shelf life and promote sustainable tomato supply chains

Introduction

Tomato is one of the most important vegetable crops because of its nutritional value, wide consumption and economic importance (Biradar et al., 2026). However, tomatoes are highly perishable and may develop several diseases after harvesting. Fungal and bacterial infections can cause soft rot, mould growth, discolouration, tissue breakdown and rapid loss of market quality (Sunkad et al., 2022). These problems may occur during harvesting, handling, transportation, storage and marketing.

Causes and Effects of Postharvest Diseases

Postharvest diseases are often associated with mechanical injuries, poor sanitation, high temperature and unsuitable storage conditions. Pathogens can enter tomato fruits through cuts, bruises and damaged tissues. Once infection begins, the disease may spread rapidly from one fruit to another. Therefore, effective disease management should not depend on a single treatment. An integrated approach that combines conventional practices with advanced technologies can provide safer, more efficient and sustainable protection (Mediga et al., 2026).

Conventional Practices for Disease Management

Conventional management begins with careful harvesting and proper handling. Tomatoes should be harvested at the appropriate maturity stage and handled gently to avoid bruising and skin damage. Damaged, overripe and diseased fruits should be removed during sorting and grading. Clean harvesting containers, tools and packaging materials are also important because they reduce the spread of disease-causing microorganisms.

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Importance of Proper Storage

Proper storage is another essential component of disease management. Suitable temperature and relative humidity can slow fruit ripening and reduce the growth of many pathogens. However, excessively low temperatures may cause chilling injury and reduce tomato quality. Good ventilation and clean storage facilities are therefore necessary.

Conventional approaches such as refrigeration, heat treatments, modified-atmosphere storage and approved sanitising treatments can help reduce postharvest losses. Their effectiveness depends on proper application and suitable storage conditions.

Biological and Natural Disease-Control Methods

Biological and natural treatments are also becoming important in postharvest disease management. Beneficial microorganisms can suppress disease-causing pathogens by competing for nutrients and space or by producing natural antimicrobial compounds.

Plant extracts (Biradar et al, 2021c), bioagents (Biradar et al., 2021b) organic acids and edible coatings (Biradar et al., 2021a) may provide additional protection. Edible coatings form a thin protective layer around the tomato, reducing moisture loss and slowing quality deterioration. These approaches may reduce dependence on chemical treatments and support environmentally responsible postharvest management.

Advanced Technologies for Early Disease Detection

Advanced technologies including multi-omics (Biradar P. and Namrata, 2024; Rao and Sunkad, 2024), genetic engineering (Biradar Pratiksha et al., 2023), genome sequencing (Biradar et al., 2023), gene editing (Patait Neha et al., 2024), are improving the early detection and control of postharvest diseases. Hyperspectral imaging can examine tomatoes at many wavelengths beyond normal human vision. It may identify small changes in moisture, pigments and tissue structure before clear symptoms become visible (Patil et al., 2026).

When combined with machine-learning algorithms, hyperspectral information can be used to classify healthy and infected fruits rapidly. Early identification allows diseased tomatoes to be separated before the infection spreads to healthy fruits (Patil et al., 2023).

Artificial Intelligence and Smart Monitoring

Artificial intelligence and computer vision can support automated disease detection and sorting. Cameras installed on grading lines can inspect large numbers of tomatoes and identify fruits with visible defects.

Smart sensors and Internet of Things systems can continuously monitor temperature, humidity and other storage conditions. When unfavourable conditions are detected, the system can provide warnings so that corrective action can be taken quickly. These technologies can improve decision-making and reduce losses during storage and transportation.

Emerging Non-Thermal Technologies

Emerging non-thermal technologies, including ultraviolet treatment, cold plasma, ozone-based washing,

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ultrasound and electrolysed water, are being investigated for reducing microbial populations while maintaining important quality characteristics. These methods may provide alternatives or supplements to conventional chemical treatments.

Advanced packaging technologies, including active packaging, antimicrobial packaging and smart packaging, can also help maintain tomato quality. Some smart packaging materials can indicate changes in temperature, freshness or storage conditions.

Integrating Conventional and Advanced Approaches

The future of tomato disease management lies in combining these methods rather than replacing conventional practices completely. Good sanitation, careful handling and appropriate storage remain the foundation of postharvest disease management.

Advanced imaging, artificial intelligence, smart sensors and novel preservation technologies can add early detection, rapid decision-making and improved disease control. Combining conventional and advanced approaches can provide more reliable protection than using a single method.

Conclusion

Integrated management of postharvest diseases in tomato combines practical knowledge with modern technology. This approach can reduce postharvest losses, improve fruit quality, extend shelf life and increase returns throughout the tomato supply chain. By adopting both conventional and advanced techniques, farmers, traders, storage operators and the food industry can contribute to a safer, more efficient and sustainable tomato production and marketing system.

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Nature's Tiny Pharmacists: Healing Secrets from the Insect World

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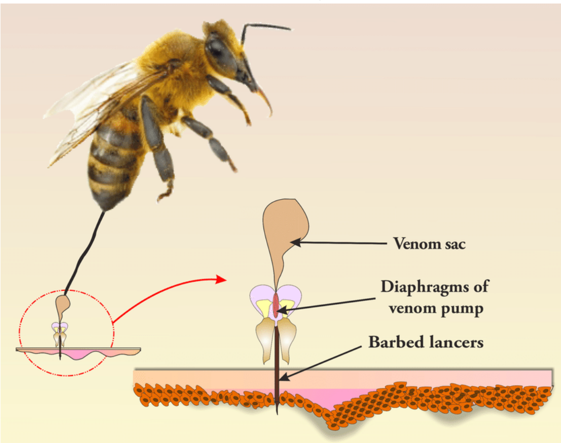
Medicinal insects are the insects that are used to prevent or treat diseases in humans. For thousands of years, different cultures around the world have used insects and their products as natural medicine. This practice is known as entomotherapy.

Therapeutic Benefits: Insects are valuable sources of natural medicine due to their high concentration of nutrients and active ingredients, which include:

- **Antimicrobial and Antibiotic Properties:** Used to fight infections.
- **Antitumor Activity:** Studied for cancer treatment applications.
- **Wound Healing:** Enabled by maggot therapy and certain insect oils.
- **Anti-inflammatory Effects:** Effective for managing conditions like arthritis

The following insects are used in manufacture of different drugs and used in curing human ailments.

1. **Honey bees:** The stings of honey bee are said to have remedial value in the treatment of arthritis and rheumatism. A specific medicine (Homeopathic), Apis is extracted from the honey bees by digesting the excited bees in alcohol and is used against certain diseases like urinary irritations, diphtheria *etc*. The honey is also used in wound healing, cough suppressant, antibacterial agent. The propolis acts as antimicrobial and will boost the immune system.



Honey bee sting (Qeios, 2026)


Bee pollen collection by worker honey bee Burlesons (2026)

2. **Blister beetles:** Cantheridin is a substance found in the blister beetle, *Lytta vesicatoria* and is useful internally treating certain urinary diseases and externally as a vesicant and counter irritant. It is also

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probably the world's best known and most widely abused aphrodisiac. It is also known to be a tonic for hair. However, it has profound physiological effects on human body and its use in medicine is how banned because of its high toxicity.

Blister beetle, *Lytta vesicatoria* (Meloidae.com, 2026)

3. **Blatta medicines:** Dr. William Boericke, a renowned homeopath, mentioned two drugs that are prepared from cockroaches, *Blatta americana* for urinary disorders like relieving from the burning sensation during urination, reducing the kidney inflammation, and also useful in curing extreme tiredness, and low vitality and also general physical exhaustion, recovery from edematous condition. *Blatta orientalis* is used for curing respiratory disorders like asthama, bronchitis, chronic cough.

Blatta Americana (Sanita ambientale, 2026)

Blatta orientalis (Obseration.org, 2026)

4. ***Ophiocordyceps sinensis*:** Caterpillar fungus it is prepared from caterpillars of *Ophiocordyceps sinensis* is used as a tonic by the Chinese athletes for strengthening and rejuvenating the body, to relieve stress, protect lungs and strengthen immune system. Due to its medicinal properties, it has been called the Chinese medicine for eternal youth"

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5. **Alleppo galls**: These galls also called as Oak galls formed on oak trees. The galls are caused by cynipid wasps (Cynipidae: Hymenoptera). They are rich in tannins. These tannins are having high medicinal value along with the gallic acid and ellagic acid. In Europe and West Asian countries, these galls are used as a powerful astringent tonic and antidote for certain poisons and also used for the antimicrobial activity to prevent infection around the human wounds. These secretions also useful to cure the chronic diarrhea, intestinal infections, and excessive mucus secretion in the gut.


Alleppo oak galls (Audrey J. Brandt, 2026)

6. **Maggot therapy**: Use of maggots of certain flies to clean wounds and promote healing has been used for centuries in some societies. Allantoin is a substance isolated from the secretions of fly maggots which seems to have properties of healing deep wounds.

7. **Ants (*Polyrhachis dives*):** This is the species of weaver ant. It is traditionally used in East Asia medicine especially in china. The whole ant or its secretions consists of proteins, amino acids, minerals like zinc, iron and other bioactive compounds. The secretions having the medicinal properties like immunomodulatory, anti-inflammatory, antioxidant, anti-fatigue and also having aphrodisiac and hepatoprotective activity.


Polyrhachis dives, (Wikipedia, 2026)

8. **Grasshoppers:** Grasshoppers are used as diuretic, anti-inflammatory, and also arthritis management such as joint pain and stiffness. They are having antioxidant properties.
9. **Wasps:** Wasp venom is noted for containing antibiotic and potential antitumor properties

Other Applications

✓ **Sutures:** Soldier ants (Army ants) have been used to close wounds due to their strong mandibles and the antibiotic properties in their saliva.

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Using ants as sutures (Reddit, 2026)

- ✓ **Nutraceuticals:** Insects, such as crickets, are consumed for high-value protein and probiotic content.

Conclusion

While many insects offer therapeutic value, there are potential risks, such as the transmission of parasites like nematodes if certain species, such as grasshoppers, are not prepared correctly. Further research is needed to fully explore the medicinal potential of many insect species.

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Conjunctive Use of Irrigation in Tank Command Areas

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1. Introduction

Water has always been the foundation of agriculture. In Tamil Nadu, where rainfall is seasonal and often unpredictable, irrigation tanks have supported farming communities for centuries. These tanks collect and store rainwater during the monsoon and distribute it to agricultural fields through a network of channels. Besides providing irrigation, tanks recharge groundwater, support livestock, conserve biodiversity, and maintain the ecological balance of rural landscapes.

Over time, however, many tanks have lost their original storage capacity due to silt accumulation, encroachments, poor maintenance, and erratic rainfall. As a result, the water stored in tanks is often insufficient to meet the irrigation needs of crops throughout the growing season. Farmers therefore increasingly depend on wells and bore wells to bridge the gap between water demand and supply. Excessive groundwater pumping, however, can lower the water table and threaten the sustainability of agriculture.

A practical solution to this challenge is the **conjunctive use of irrigation**, which combines tank water and groundwater in a planned and balanced manner. Instead of relying entirely on one source, farmers make the best use of both resources. This approach not only ensures a reliable water supply but also improves water-use efficiency, enhances crop production, and protects groundwater resources for future generations.

2.Conjunctive Use of Irrigation

Conjunctive use of irrigation is the coordinated use of **surface water stored in irrigation tanks** and **groundwater obtained from open wells or bore wells**. The basic principle is simple: whenever sufficient tank water is available, it should be used for irrigation. As tank storage decreases or becomes exhausted, groundwater is used to supplement irrigation requirements.

2.1. Importance of Conjunctive Use in Tank Command Areas

Agriculture in tank command areas depends largely on the northeast and southwest monsoons. During years of good rainfall, tanks fill up and provide sufficient irrigation while simultaneously recharging groundwater. During drought years or prolonged dry spells, however, tank storage declines rapidly, leaving farmers dependent on groundwater. Using only tank water is risky because storage may not last until the end of the cropping season. On the other hand, depending solely on groundwater can lead to declining water tables, higher pumping costs, and drying of wells. Conjunctive use offers a balanced solution by integrating both resources. It ensures a dependable water supply while maintaining groundwater at sustainable levels.

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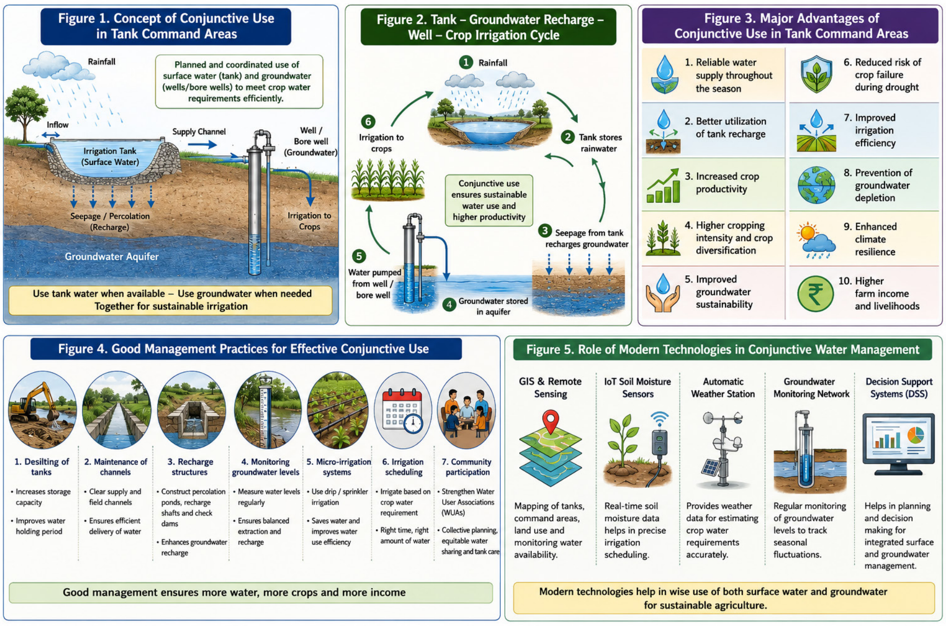

Figure 1. Concept of Conjunctive Use of Tank Water and Groundwater

2.2. Advantages of Conjunctive Use

2.2.1. Reliable Water Supply throughout the Crop Season

One of the greatest advantages of conjunctive use is the assurance of irrigation throughout the crop-growing period. Farmers can use tank water during the early stages of crop growth and switch to groundwater when tank storage becomes insufficient. This flexibility prevents interruptions in irrigation and protects crops from moisture stress during critical growth stages such as flowering and grain filling.

2.2.2.Better Utilization of Tank Recharge

Many people consider seepage from irrigation tanks as a loss. In reality, seepage performs an important ecological function by recharging underground aquifers. The groundwater stored beneath the tank command area can later be pumped through wells for irrigation. Thus, conjunctive use transforms what appears to be water loss into a valuable source of irrigation, significantly increasing the overall efficiency of water use.

2.2.3. Increased Crop Productivity

Timely irrigation is essential for healthy crop growth. When crops receive adequate moisture throughout the growing season, they develop stronger root systems, absorb nutrients more efficiently, and produce higher yields. Conjunctive use reduces water stress during critical growth stages, leading to better crop performance, improved grain quality, and increased agricultural productivity.

2.2.4. Higher Cropping Intensity and Crop Diversification

Reliable irrigation encourages farmers to cultivate more than one crop each year. Instead of leaving land fallow after the monsoon season, farmers can grow pulses, oilseeds, vegetables, fodder crops, and other high-value crops using supplemental groundwater irrigation. This increases cropping intensity, diversifies farm production, and provides additional sources of income.

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2.2.5. Sustainable Groundwater Management

Groundwater is one of the most valuable natural resources available to farmers. However, excessive pumping without adequate recharge eventually leads to declining water tables. Conjunctive use promotes sustainable groundwater management by encouraging the use of tank water whenever available while allowing natural seepage from tanks to replenish aquifers. Maintaining this balance between recharge and extraction helps ensure groundwater availability for future generations.

2.2.6. Reduced Risk of Crop Failure

Agriculture in semi-arid regions is highly vulnerable to uncertain rainfall. Even a short dry spell during flowering or grain development can significantly reduce yields. Groundwater serves as a dependable backup source during such periods, providing life-saving irrigation that protects crops from drought and minimizes production losses.

2.2.7.Improved Irrigation Efficiency

Efficient irrigation means applying the right quantity of water at the right time. Conjunctive use allows farmers to allocate tank water and groundwater according to crop requirements and seasonal availability. When combined with modern irrigation methods such as drip and sprinkler systems, this approach minimizes water losses due to evaporation and deep percolation, resulting in higher water productivity.

2.2.8. Greater Resilience to Climate Change

Climate change has increased the occurrence of erratic rainfall, prolonged droughts, and unpredictable weather conditions. Having access to both surface water and groundwater makes farming systems more resilient. Farmers can adjust irrigation practices according to changing climatic conditions, reducing the risks associated with weather uncertainty.

2.2.9. Increased Farm Income

Reliable irrigation translates into higher crop yields, better-quality produce, and improved economic returns. Farmers can cultivate high-value crops, extend the cropping season, and reduce the likelihood of crop failure. These benefits collectively enhance household income and improve the overall livelihood of farming families.

3. Management Practices for Successful Conjunctive Use

The success of conjunctive irrigation depends on proper planning and regular maintenance. Irrigation tanks should be desilted periodically to restore their storage capacity, while supply and field channels must be maintained to ensure efficient water distribution. Recharge structures such as percolation ponds and recharge wells can further enhance groundwater replenishment. Farmers should monitor groundwater levels regularly and adopt scientific irrigation scheduling based on crop water requirements. Water-saving technologies such as drip and sprinkler irrigation should be promoted to improve irrigation efficiency. Active participation of Water User Associations (WUAs) is equally important for ensuring equitable distribution of water and proper maintenance of tank systems.

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4. Role of Modern Technologies

Modern technologies provide powerful tools for improving conjunctive water management. Geographic Information Systems (GIS) and remote sensing help monitor tank storage, command area conditions, and groundwater recharge. Automatic weather stations and soil moisture sensors enable farmers to schedule irrigation more accurately. Decision Support Systems (DSS), groundwater models, and mobile-based advisory services assist irrigation managers and farmers in making informed decisions for efficient use of both surface water and groundwater.

5. Relevance to Tamil Nadu

Tamil Nadu possesses one of the largest traditional tank irrigation systems in India. These tanks have sustained agriculture for generations while supporting groundwater recharge and rural livelihoods. Government initiatives such as **Kudimaramathu**, tank rehabilitation programmes, participatory irrigation management, and watershed development projects have revived many tank systems across the state. By integrating tank water with groundwater, Tamil Nadu can improve irrigation reliability, increase water-use efficiency, reduce groundwater depletion, and strengthen the resilience of agriculture against climate change. Conjunctive use is therefore an important component of sustainable water resource management in the state.

6.Conclusion

Conjunctive use of tank water and groundwater is much more than an irrigation practice—it is a sustainable approach to managing precious water resources. By using both sources wisely, farmers can ensure dependable irrigation, increase crop productivity, protect groundwater, and improve their livelihoods. At the same time, this approach conserves natural resources and strengthens the resilience of agriculture against climate variability. As water becomes an increasingly scarce resource, adopting conjunctive use in tank command areas will be essential for achieving sustainable agricultural development. With scientific planning, regular tank maintenance, modern irrigation technologies, and active community participation, conjunctive water management can secure the future of farming in Tamil Nadu and other tank-irrigated regions of India.

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El Nino and Fish Farming: Strategies for Climate-Resilient Aquaculture

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Abstract

El Nino-Southern Oscillation (ENSO) is an important climatic phenomenon that can influence rainfall, temperature and water availability, creating challenges for aquaculture production. El Nino -associated climatic variability may reduce pond water levels, increase water temperature, alter dissolved oxygen dynamics and affect fish feeding, growth and health. These environmental changes can also increase the risk of water quality deterioration and disease outbreaks, particularly in intensively managed systems. Climate-resilient aquaculture therefore requires proactive farm level management, including adequate water conservation, appropriate stocking density, regular monitoring of temperature, dissolved oxygen, pH and ammonia, efficient feeding and reliable aeration. Strengthening biosecurity and using local weather forecasts and seasonal climate information can further improve preparedness. Climate-smart technologies such as IoT-based water quality monitoring, automated feeding, recirculating aquaculture systems and well managed biofloc systems offer additional opportunities for adaptation. Integrating these measures can improve farm resilience, resource use efficiency and sustainable fish production under increasing climatic variability.

Keywords: Aquaculture, Climate Resilience, Fish Farming, Water Management

Introduction

Aquaculture production is closely dependent on temperature, rainfall, water availability and water quality. Variations in these factors can alter fish metabolism, feeding, dissolved oxygen dynamics and disease risk, thereby affecting farm productivity. El Niño is the warm phase of the El Nino -Southern Oscillation (ENSO) a coupled ocean-atmosphere phenomenon that can influence rainfall and temperature over distant regions. Its relationship with the Indian summer monsoon is significant but not uniform; therefore, an El Nino event should be treated as an indicator of climatic risk rather than as a direct prediction of local rainfall (Roy and Tedeschi, 2019; Goswami and An, 2023). For fish farmers, the practical objective is to anticipate possible water and thermal stress and adjust pond management accordingly.

1.Effects of El Nino -Associated Climate Stress on Fish Farming

1.1. Reduced Rainfall and Water Availability

Reduced or irregular rainfall can increase dependence on groundwater, canals or other supplementary sources, while higher evaporation may lower pond water levels. Reduced water volume can increase the concentration of ammonia and other metabolites, intensify temperature fluctuations and reduce the dilution of pollutants. Water scarcity and deterioration of water quality are recognized as important climate-related constraints to aquaculture, making water conservation and adaptive management essential (Galappaththi *et al*., 2020).

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1.2. Higher Water Temperature

Fish are ectothermic and therefore respond directly to changes in water temperature. Prolonged warming can alter metabolic rate, feeding activity, growth and oxygen demand, while thermal stress may also increase susceptibility to disease. Maintaining adequate pond depth and avoiding unnecessary handling during periods of high temperature can reduce additional stress. Temperature management should be considered together with dissolved oxygen and feeding decisions rather than as an isolated parameter.

1.3. Dissolved Oxygen: The Critical Factor Dissolved oxygen is a key determinant of fish survival and production. Warm water holds less oxygen, while fish and microbial respiration may increase under higher temperatures. Oxygen depletion is particularly likely during early morning hours, prolonged cloudy weather, algal-bloom collapse and decomposition of excess organic matter. Overfeeding can further increase microbial oxygen demand. Consequently, DO should be monitored regularly during climatic stress, with particular attention to early-morning values. Intensive and semi-intensive farms should maintain adequate aeration capacity and use aerators in response to DO measurements, fish behaviour and pond conditions.

1.4. Feed Management During Climate Stress

Feed is a major component of aquaculture production cost and becomes especially important when environmental conditions reduce feeding activity. Uneaten feed increases organic loading and may contribute to higher ammonia and oxygen demand. Feed should therefore be based on actual biomass and observed feeding response, with adjustment for temperature, DO and fish activity. Excess feeding should be avoided during severe heat or poor water quality. Climate variability may also affect the availability and cost of feed ingredients; Jannathulla *et al*. (2019) highlighted the need for sustainable alternative protein sources and improved aquafeed strategies in the context of climate-related pressure on fishmeal resources.

1.5. Increased Risk of Fish Diseases

Climatic stress can interact with host condition, water quality and pathogen activity and may increase disease risk. Warm tropical conditions can favour more rapid development of some aquaculture diseases (Leung and Bates, 2013). Farmers should therefore maintain good water quality, avoid excessive stocking, remove dead fish promptly and maintain pond hygiene. Newly introduced seed should be observed and quarantined where practicable and fish should be inspected for ulcers, haemorrhages, abnormal swimming, excessive mucus and external parasites. Suspected disease should be professionally diagnosed before antibiotics or other therapeutants are applied. Prevention and early diagnosis are preferable to indiscriminate treatment.

1.6. Pond Water Quality Monitoring Becomes Essential

During climate-stress periods, regular measurement of temperature, DO, pH, ammonia, transparency, alka-

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linity and water level provides an early indication of deteriorating pond conditions. Maintaining simple farm records helps identify trends and supports timely decisions on feeding, aeration and water management.

2.Practical Climate-Resilient Strategies for Fish Farmers

2.1. Before the El Nino /Hot-Dry Period

Ponds should be prepared before climatic stress develops. Damaged bunds and inlet/outlet structures should be repaired, excessive vegetation and organic matter removed and feasible emergency water sources identified. Adequate pond depth should be maintained to reduce rapid temperature fluctuations and evaporative water loss. Aerators, pumps and electrical connections should be checked with backup power or alternative aeration arrangements available where possible. Stocking density should be reviewed against pond carrying capacity, available water and aeration capacity; unnecessarily high biomass increases oxygen demand, organic loading and disease risk.

2.2. During the Climate-Stress Period

A simple management framework is to Monitor, Maintain, Modify, Minimize and Manage. Monitor water quality and fish behaviour regularly. Maintain adequate water depth and oxygen availability. Modify feeding according to fish appetite and environmental conditions. Minimize unnecessary handling, overfeeding and organic loading. Manage problems early when abnormal behaviour, oxygen depletion, poor water quality or disease signs appear. This approach emphasizes prevention and timely correction rather than emergency intervention.

2.3. Role of Aeration

Aeration is particularly important at high biomass and when DO declines, but it cannot replace appropriate stocking, feeding and organic-matter management. Biofloc, nursery and other high-density systems require especially reliable aeration because oxygen can decline rapidly after an interruption. Farmers should inspect equipment regularly and where feasible, maintain generators, battery supported systems or other backup arrangements.

3.Use Climate Information for Farm Decisions

Aquaculture management should increasingly use available climate and weather information for planning rather than responding only after a problem occurs. Seasonal rainfall and temperature forecasts, drought and extreme-weather warnings, local water availability and farm water-quality records can inform decisions on stocking, feeding, water management and aeration. ENSO information should not be used alone because its relationship with local Indian rainfall is variable. It is more useful when combined with local forecasts, seasonal advisories and real time pond observations (Roy and Tedeschi, 2019; Goswami and An, 2023).

4.Climate-Smart Aquaculture Technologies

Climate resilience can be strengthened through appropriate technology. IoT-based sensors can provide continuous measurements of temperature, DO and pH and generate alerts when conditions deteriorate. Automated feeding can reduce feed wastage when linked to fish activity and environmental observations. Recirculating aquaculture systems can reduce dependence on external water by treating and reusing culture water, although

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they require technical skill and energy. Biofloc systems improve nutrient recycling and water use efficiency but require close management and dependable aeration. In the longer term, selecting species or strains suited to local thermal and water conditions may contribute to adaptation. Reviews of climate adaptation emphasize that no single technology is sufficient; farm management, infrastructure, technology and institutional support need to work together (Galappaththi *et al*., 2020).

5. El Nino Is a Warning Signal-Not a Reason to Stop Fish Farming

The effect of El Nino on a fish farm depends on the event, local weather, pond characteristics, species and management. Farms are more vulnerable when water reserves are inadequate, stocking is excessive, aeration is poor, feeding is uncontrolled and disease surveillance is weak. Conversely, adequate water storage, suitable pond depth, reliable aeration, regular monitoring and flexible feeding improve preparedness. Thus the appropriate response is not to stop aquaculture but to anticipate climatic risks and adjust management according to actual pond conditions.

Conclusion

El Nino demonstrates the close relationship between climate and aquaculture production. Changes in rainfall, temperature and water availability can affect pond ecology, oxygen dynamics, feeding, growth and fish health. Climate-resilient aquaculture therefore depends on preparedness conserving water, maintaining suitable pond conditions, monitoring water quality, ensuring aeration, controlling feeding, strengthening biosecurity and using reliable climate information. The objective is not simply higher production, but efficient, safe and sustainable fish production under variable environmental conditions.

"Prepare the pond before climatic stress occurs-prevention is the foundation of resilient aquaculture."

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Soil Quality: The Living Foundation Of Sustainable Agriculture

Healthy Soil, Healthy Crops, Healthy Future

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Why Healthy Soil Matters

When we look at a healthy agricultural field, we usually notice the crop first—the green leaves, strong stems, flowers and developing fruits. But beneath that visible growth lies an equally important world that often receives far less attention: the soil.

Soil is not simply a medium in which plants grow. It is a living, dynamic ecosystem containing minerals, organic matter, water, air, microorganisms, fungi, earthworms and countless other organisms. Together, these components support plant growth, regulate water, recycle nutrients and maintain the ecological functions on which agriculture depends.

For farmers, healthy soil is one of the most valuable assets on the farm. Unlike machinery or buildings, however, soil cannot be replaced easily once it has been seriously degraded.

What Makes Soil Healthy?

Soil quality refers to the ability of soil to perform its essential functions effectively. These include supporting plant growth, storing and supplying water, cycling nutrients, maintaining biological activity and providing a suitable environment for roots and soil organisms.

Soil quality is generally considered through three broad groups of properties: physical, chemical and biological. Physical properties include soil structure, texture, porosity, compaction, water infiltration and water-holding capacity. Chemical properties include soil pH, nutrient availability, salinity and organic carbon. Biological properties include microbial activity, earthworms, fungi and other organisms living in the soil.

A productive soil needs a balance among all three. A soil may contain adequate nutrients but still perform poorly if it is severely compacted or biologically inactive.

A Hidden World Beneath Our Feet

One of the most fascinating characteristics of soil is its biodiversity. Millions of microscopic organisms and numerous larger organisms live in soil. Bacteria and fungi break down organic materials and participate in nutrient cycling. Earthworms and other soil fauna help influence soil structure and the movement of water and air.

The Food and Agriculture Organization of the United Nations (FAO) recognizes soil biodiversity as an important component of ecosystem functioning, contributing to nutrient cycling, plant health and several ecosystem services (FAO, 2020).

This means that when we protect soil organisms, we are also protecting some of the natural

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processes that make agriculture possible.

Organic Matter: The Engine of Soil Health

Organic matter is one of the most important components of healthy soil. Crop residues, fallen leaves, roots, animal manures and other organic materials enter the soil and undergo decomposition. During this process, microorganisms transform organic materials and release nutrients.

Organic matter also contributes to soil structure and water-holding capacity and provides an energy source for soil organisms. For this reason, crop residues should not always be regarded as waste. When appropriately managed, they can become an important resource for maintaining soil health.

When Soil Begins to Degrade

Soil degradation can occur gradually. Farmers may not notice the problem immediately, but declining soil structure, reduced organic matter, erosion, nutrient imbalance and loss of biological activity can eventually affect crop productivity.

Soil Erosion

Water and wind can remove valuable topsoil. The upper soil layer often contains a high proportion of organic matter and nutrients required for plant growth. Maintaining vegetation, crop residues or other forms of soil cover can help protect the surface from erosion.

Soil Compaction

Repeated movement of heavy machinery can compact soil and reduce the spaces through which air and water move. Compacted soil may restrict root growth and reduce water infiltration. Avoiding unnecessary field traffic and adopting appropriate conservation practices can help reduce this problem.

Nutrient Imbalance

Crops continuously remove nutrients from the soil. If nutrients are not replaced appropriately, soil fertility can decline. However, adding more fertilizer is not always the answer. Excessive fertilizer use can cause nutrient imbalances and environmental problems. Soil testing and balanced nutrient management are therefore essential.

Declining Soil Biodiversity

Intensive disturbance, pollution and inappropriate land-management practices can affect soil organisms. A reduction in soil biodiversity may interfere with important processes such as decomposition and nutrient cycling. Maintaining diverse crops, organic inputs and suitable soil conditions can help support soil biological communities.

Four Simple Principles for Better Soil

1. Keep the Soil Covered — Bare soil is more vulnerable to erosion and moisture loss. Crop residues, mulch and cover crops can provide protection.

2. Minimize Soil Disturbance — Excessive tillage can disturb soil structure and soil organisms. Reduced or conservation tillage can be considered where appropriate for local conditions.

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3. Keep Living Roots in the Soil — Living roots interact continuously with soil microorganisms and contribute organic materials to the soil. Cover crops can help maintain living roots between major cropping periods.

4. Increase Crop Diversity — Different crops have different root systems and nutrient requirements. Crop rotation and diversified cropping systems can support soil biological diversity and improve the resilience of farming systems (USDA-NRCS, n.d.).

Crop Rotation: Diversity Above and Below Ground

Growing the same crop repeatedly can place continuous pressure on soil nutrients and may encourage certain pests and diseases. Crop rotation introduces different crops into the production system. Different crops contribute different types of residues and root systems, creating a more diverse below-ground environment.

Including suitable legumes in rotations can also contribute to nitrogen cycling through biological nitrogen fixation. Crop rotation is therefore not simply a way of changing crops—it is a way of changing and diversifying the biological environment of the soil.

Cover Crops: Protecting Soil Between Crops

After harvesting a main crop, leaving the soil completely bare can expose it to erosion and moisture loss. Cover crops provide living vegetation during periods when the main crop is absent. Their roots interact with soil organisms, while their above-ground biomass can protect the soil surface.

Cover crops should be selected according to local rainfall, irrigation availability, soil type, crop rotation and farming objectives.

Soil and Water: A Critical Partnership

Healthy soil plays a major role in water management. Well-structured soil allows water to infiltrate and move through the soil profile. Some of that water can be stored and later become available to plants.

Poorly structured or compacted soils may have reduced infiltration, resulting in greater surface runoff and erosion. Thus, improving soil health can also improve the efficiency with which agricultural landscapes receive, store and use rainfall.

Soil and Climate Change

Soil is an important part of the global carbon cycle. Plants capture carbon dioxide from the atmosphere through photosynthesis. Carbon then enters plant tissues and, through roots and residues, can enter the soil.

Soil management influences the movement and storage of carbon as well as other biological processes. Protecting soil should not be presented as a single solution to climate change, but maintaining soil organic matter and biological activity is an important component of building resilient agricultural systems.

How Can Farmers Measure Soil Health?

A farmer cannot determine soil health from crop yield alone. Soil-health assessment can include physical, chemical and biological indicators. Important measurements and observations may include soil

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organic matter, soil pH, available nutrients, soil structure, compaction, water infiltration, biological activity, root growth, soil cover, and earthworm and other soil-organism activity.

USDA-NRCS emphasizes that soil health is best understood through a combination of indicators rather than a single measurement (USDA-NRCS, n.d.). Regular soil testing, combined with field observation, can help farmers identify problems early and evaluate whether management practices are improving soil function.

Building Better Soil for Indian Agriculture

India has enormous diversity in soil types, climate, crops and farming systems. Therefore, there is no single soil-management practice that can be recommended universally.

The best approach is to combine soil testing, scientific recommendations and local farming knowledge. Practices such as balanced fertilization, crop rotation, appropriate organic-matter management, erosion control, efficient water management and suitable conservation practices can contribute to long-term soil health when adapted to local conditions. Farmers should also avoid adopting any practice simply because it is popular. Soil-management decisions should be based on the characteristics of the individual field and the needs of the cropping system.

What Can Farmers Do Today?

Keep soil covered whenever possible.

Reduce unnecessary tillage.

Practice suitable crop rotations.

Use appropriate cover crops.

Return suitable organic materials to the soil.

Apply fertilizers according to soil-test results and crop requirements.

Reduce erosion through appropriate land management.

Avoid unnecessary soil compaction.

Encourage soil biodiversity.

Monitor soil properties regularly.

The most effective results often come from combining several practices rather than depending on a single intervention.

Soil Conservation Is Everyone’s Responsibility

Although farmers are the primary stewards of agricultural soil, soil conservation is a broader societal responsibility. Urban expansion covers productive land with roads and buildings. Improper waste disposal can contaminate soil. Deforestation and inappropriate land use can accelerate erosion.

Consumers, communities, researchers and policymakers all have roles to play in protecting this

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essential resource. Supporting sustainable agricultural practices and improving awareness about soil health can help ensure that productive soils remain available for future generations.

The Future of Agriculture Begins Beneath Our Feet

Agriculture is rapidly adopting new technologies. Drones, sensors, artificial intelligence, precision farming, improved varieties and smart irrigation systems are transforming the way farmers manage their fields.

But even the most advanced technology cannot replace healthy soil. A high-yielding crop still needs a functioning root zone. Roots still need water, nutrients, air and biological support. The future of agriculture therefore depends not only on what happens above the ground, but also on what happens below it.

Conclusion

Soil may appear quiet and lifeless, but beneath its surface is a complex and dynamic ecosystem. Healthy soil supports crops, stores and regulates water, cycles nutrients, provides habitat for biodiversity and contributes to resilient agricultural systems.

At the same time, soil is vulnerable to erosion, compaction, nutrient imbalance, loss of organic matter and degradation of its biological community.

Protecting soil requires a long-term perspective. Keeping the soil covered, maintaining living roots, diversifying crops, reducing unnecessary disturbance and managing nutrients carefully can help preserve its productive capacity.

Healthy soil is more than the foundation of a good harvest. It is the foundation of food security, environmental sustainability and the future of farming.

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Contingency Crops and Fodder Security: Key Priorities for Farmers of Annamayya District under Drought Conditions

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At present, the normal rainfall during the Kharif season in Annamayya District is 239.1 mm, whereas only 61.2 mm has been recorded, resulting in a 74.4% rainfall deficit compared with normal rainfall. The situation has been classified as scanty rainfall. Agriculture in Annamayya District is predominantly dependent on rainfed conditions. Major crops grown in the district include groundnut, redgram, paddy, maize, finger millet, and cowpea, along with horticultural crops such as mango, papaya, and tomato. Animal husbandry also plays an important role in the livelihoods of rural farming families. Many farmers earn additional income through the rearing of cattle, sheep, and goats. Agriculture and livestock production are closely interconnected, as crop residues such as groundnut haulms, paddy straw, maize residues, and other crop residues serve as important sources of livestock fodder.

However, drought, delayed rainfall, or prolonged dry spells can adversely affect not only crop yields but also the availability of fodder. In particular, a reduction in the area under groundnut may lead to reduced availability of groundnut haulms and consequently create a fodder shortage. Therefore, to cope with drought conditions, it is essential to develop an integrated action plan covering alternative crop planning, fodder production, fodder storage, and livestock protection.

Alternative Crops under Drought Conditions:

Among alternative crops, pulses such as redgram, greengram, blackgram, cowpea, and horsegram can be considered depending on the prevailing conditions. These crops can provide yields within a relatively short duration and can also contribute to improving soil fertility as part of crop rotation. Horsegram is particularly well suited to the agro-climatic conditions of Annamayya District. Among millets, finger millet, foxtail millet, and pearl millet are good alternatives under low-water conditions and have special importance in adapting agriculture to climate variability. Similarly, instead of water-intensive crops such as paddy, farmers can consider growing maize, pearl millet, finger millet, redgram, greengram, blackgram, and cowpea, depending on soil moisture and other local conditions.

Alternative Crop Plan under Delayed or Deficient Rainfall:

Farming Situation	Normal Crop/ Cropping System	August – 4th Week	September – 2nd Week	September – 4th Week
Rainfed – Light soils	Sole Groundnut	Redgram, Cowpea, Castor, Finger millet, Foxtail millet, Sorghum	Horsegram	Horsegram
Rainfed – Light soils	Groundnut + Redgram	Redgram, Cowpea, Castor, Finger millet, Foxtail millet, Sorghum	Horsegram	Horsegram

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Rainfed – Light soils	Redgram	Redgram, Cowpea, Castor, Finger millet, Foxtail millet, Sorghum	Horsegram	Horsegram
Rainfed – Light soils	Horsegram	Horsegram	Horsegram	Horsegram
Irrigated (Well/ Borewell) – Heavy soils	Groundnut	Redgram, Sorghum, Cowpea, French bean, Finger millet, Cluster bean	Cluster bean, Sorghum, Cowpea, French bean	Cluster bean, Fodder sorghum, Cowpea, French bean
Irrigated (Well/ Borewell) – Heavy soils	Paddy	Redgram, Cowpea, French bean, Sorghum, Finger millet, Leafy vegetables, Cluster bean	Redgram, Cluster bean, Sorghum, Cowpea, French bean, Leafy vegetables	Redgram, Cluster bean, Sorghum, Cowpea, French bean, Leafy vegetables

* The selection of a suitable alternative crop should be based on prevailing soil moisture, rainfall received, sowing time, soil type, seed availability, and market conditions.

Important Measures for Conserving Rainwater in the Field:

- Farmers should retain as much rainwater as possible within the field rather than allowing it to run off. This will facilitate infiltration and help conserve soil moisture for a longer period. Small field bunds may be constructed for this purpose.
- Sub-soiling at 2-metre intervals to a depth of 40–60 cm can help rainwater infiltrate into the soil through the channels created by the operation and conserve moisture. This practice is particularly suitable for dryland farming.
- In sloping lands, small water-harvesting pits or other suitable water-conservation structures should be adopted according to the soil type.
- During intermittent dry spells within the crop season, a urea solution @ 20 g per litre of water, or 19:19:19 or 13:0:45 @ 5 g per litre of water, may be applied as a foliar spray to support the crop.
- Mulching with crop residues and timely weed management can reduce evaporation and help conserve moisture required by the crop.
- With increasing temperatures, the incidence of sucking pests may increase. Therefore, crops should be monitored regularly and integrated pest-management measures should be adopted.
- During drought conditions, advance arrangements should be made to avoid fodder shortages. Available dry fodder should be stored properly without wastage, suitable short-duration fodder crops should be cultivated, balanced feed should be provided to livestock, and adequate drinking water should be ensured.

Availability of Seeds at KVK, Kalikiri: For suitable crop varieties and recommended management practices, farmers are advised to contact Krishi Vigyan Kendra, Kalikiri.The following varieties are currently available at KVK, Kalikiri: Redgram (TRG-59), Cowpea (TPTC-29) & Horsegram (Anantha Vulava).